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THE

AMERICAN JOURNAL

OF

SCIENCE AND ARTS.

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THIRD SERIES.

VOL. XII.—[WHOLE NUMBER, CXII.]

JULY TO DECEMBER, 1876.

WITH FIVE PLATES.

NEW HAVEN: EDITORS.
1876.

St

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS.

CONTENTS OF VOLUME XII.

NUMBER LXVII.

NUMBER LXVIII.

SCIENTIFIC INTELLIGENCE.

NUMBER LXIX.

SCIENTIFIC INTELLIGENCE.

NUMBER LXX.

NUMBER LXXI.

NUMBER LXXII.

ERRATA.—On page 459, 20th line from foot, for *Amherst*, read *Andover*.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. I.—*Contributions to Meteorology, being Results derived from an examination of the Observations of the United States Signal Service, and from other sources*; by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Fifth paper. With plates I and II.

[Read before the National Academy of Sciences, Washington, April 19, 1876.]

Low temperature of December, 1872.

IN my second paper (this Jour., vol. ix, p. 8) I called attention to the unusually low temperature of the latter part of the month of December, 1872. At that time I had little information upon this subject except what could be derived from the daily weather maps, and these were unsatisfactory because the telegraphic reports had failed from a large number of the most important stations. As the observations of the Signal Service have since been published in full, the phenomena of that period can now be discussed more satisfactorily.

The temperature of December, 1872, in the United States, was not remarkably low until about the middle of the month. On the morning of December 16th the sky was overcast from Lake Michigan to Lake Ontario, and there were indications of the formation of an area of low barometer in that vicinity. At this time there was an area of high barometer central over Dakota, where the highest pressure was 30·51, and there was a cold area nearly concentric with it, the greatest depression being 25° below the mean temperature of December. By 4 P. M. an area of low barometer was developed which was central over Buffalo (bar. 29·77), accompanied by light snow and rain, and at 11 P. M. this area had reached the Atlantic coast.

On the morning of the 17th the high pressure from Dakota

had moved southeastward and was central over Cincinnati (bar. 30·44). The temperature throughout this vicinity was 15° below the mean of December. At the same time another center of high pressure appeared near the northern line of Dakota, where the barometer was 30·39, and temperature 25° below the mean. On the morning of the 18th the pressure in Dakota had risen to 30·64, with a temperature 44° below the mean. During the 18th this area of high barometer stretched out towards the southeast, and on the morning of the 19th this high pressure extended, like a ridge, from the north line of Dakota to the Atlantic coast near Cape May, where the pressure was 30·52. The greatest depression of temperature was, however, west of Lake Huron, from which region the cold area extended to the Rocky Mountains. At the same time a storm, proceeding from Texas, advanced towards the northeast, and on the morning of the 20th was central over Lake Ontario (bar. 29·43). By this storm the high pressure of the 19th was crowded towards the northeast, and the temperature rose throughout the storm area; but at the same time a new area of high barometer formed in Dakota (bar. 30·37), and the thermometer sunk 34° below the mean. During the 20th this area of high pressure moved southward, and on the morning of the 21st its center was near lat. 42°, and the pressure had increased to 30·72. The cold had now become very intense, and extended over a vast area, the greatest depression being 41° below the mean, and the area of 30° depression stretched from the Rocky Mountains to Lake Michigan, a distance of 1,500 miles. It extended southward to lat. 38°, and northward beyond the limits of the United States.

On the morning of the 22d an area of low barometer formed near the Rocky Mountains, in Wyoming (bar. 29·60), and the area of high barometer was crowded towards the southeast, being now central over Cincinnati (bar. 30·65). The cold area had increased greatly in extent, advancing southward and eastward. It was most intense at Port Stanley, on Lake Erie, where the depression was 44°; but the area of 20° depression extended from the Gulf of Mexico to Canada, and from New York city westward to long. 97°.

The storm of the 22d advanced eastward, and on the morning of the 23d was central over Lake Huron. At the same time an area of high barometer formed in Dakota and Minnesota (bar. 30·60) accompanied by a very low temperature. At La Crosse the depression was 39° below the mean, and the area of 20° depression extended from Lake Huron to the Rocky Mountains, and from lat. 37° on the south to British America on the north.

On the 23d a storm center appeared in Oregon, and on the morning of the 24th the barometer at Portland, Oregon, stood at 29·15. By this storm, the area of high pressure and of low

temperature, on the east side of the Rocky Mountains, was crowded eastward. On the morning of the 24th the highest pressure was at La Crosse 30·85, and the area of 30·40 pressure extended from long. 100° to New York, and from lat. 34° on the south to British America on the north. On Plate I. are shown the isobars for this date, for each tenth of an inch variation of pressure. The greatest depression of the thermometer was at St. Louis, 45° below the mean, and the area of 20° depression extended from the Gulf of Mexico to British America, and from long. 102° to Nova Scotia. On Plate II. are drawn curves, at intervals of 5°, showing how much the temperature at each place was above or below the mean temperature of December.

On the morning of the 25th the Oregon storm had crossed the Rocky Mountains, and had crowded the high pressure of the 24th still further eastward. The pressure was now greatest over Lake Ontario, 30·66. The cold area still stretched from Texas to Nova Scotia, the depression being 42° on Lake Ontario, and 32° at Indianola, on the Gulf of Mexico. A storm was now organized over the eastern part of the Gulf of Mexico, accompanied with heavy rain in Florida and along the Atlantic coast, changing to snow as it advanced northward.

On the morning of the 26th the center of this storm was over the Atlantic Ocean near Norfolk, Va. (bar. 29·46). At the same time another area of high barometer had formed over Minnesota (30·92) accompanied by a depression of the thermometer of 31°. On the morning of the 27th this area of high pressure remained nearly unchanged in magnitude and position, but the depression of the thermometer at several places had increased to 37°. During the 27th the high pressure diminished in amount and moved towards the southeast. On the the morning of the 28th the center of high pressure was over Tennessee (30·61) and the greatest depression of the thermometer was 29°. Another storm center had already formed in the northwest, which reached the Mississippi valley on the morning of the 29th, and now at none of the stations west of the Mississippi did the depression of the thermometer exceed 16°.

The accompanying table exhibits the observed changes of temperature from Dec. 16 to Dec. 27. Column second shows the mean temperature of December at the stations named in column first, and the succeeding columns show the difference between the mean temperature of the month and the temperature observed each day at $7^h\ 35^m$ A. M. At this hour the temperature is about 4° below the mean temperature of the day, so that the numbers given in the table should all be increased by about 4° in order to show the depression below the mean temperature at the hour of observation. The depressions mentioned in the preceding description were all copied from this table.

Observations of the Thermometer at $7^h\ 35^m$ A. M., *Dec.* 16–27, 1872.

STATIONS.	Mean temp. of Dec.	ABOVE OR BELOW THE MEAN TEMPERATURE.											
		Dec. 16.	Dec. 17.	Dec. 18.	Dec. 19.	Dec. 20	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec. 27.
Portland, Or.,	39°	-7	-6	-5	-5	0	-6	+7	....	+12	+9	+9	+11
San Francisco,	52	-9	-11	-11	-11	-10	-6	-9	-3	+3	+8	+8	+1
San Diego,	55	-10	-3	-12	-9	-10	-9	-12	-5	0	0	0	+3
Corinne,	28	-12	-6	-1	-20	0	-22	+6	+7	+14	+8	+7	+7
Virginia City,	19	-1	-9	-20	-24	-19	-37	+11	-36	-7	+14	+3	+13
Fort Benton,	11	-5	-12	-44	-15	-18	-41	-11	-26	-14	-19	-22	-22
Santa Fe,	31	-11	-10	-17	-16	-17	-8	-13	-8	-10	+5	-4	+4
Denver,	26	-14	-20	-19	-28	-15	-31	+14	-19	-8	+19	+1	-4
Cheyenne,	26	-19	-22	-6	-33	-27	-33	+6	-32	0	+11	-11	+6
Fort Sully,	13	-18	-6	-24	-27	-36	-38	-11	-36	-17	-13	-28	-14
Pembina,	-4	....	-25	-26	-21	-26	-31	-12	-30	-33	-10	-25	-33
Indianola,	54	-10	-11	-5	-7	-16	-7	-22	-8	-27	-32	-22	-31
Omaha,	20	-17	-12	-11	-19	-22	-36	9	-34	-32	17	-26	-27
Breckenridge,	4	-20	20	-32	-27	-34	-36	-14	-37	-25	-16	-31	-37
Leavenworth,	26	-15	-17	-15	-15	-29	-28	-15	-30	-39	-26	-30	-30
Galveston,	56	-8	-12	-4	+7	-12	-10	-21	-7	-21	-29	-24	-30
Shreveport,	47	-9	-10	-9	-10	17	-21	-27	-5	-25	-30	-21	-32
St. Paul,	11	-16	-6	-16	-25	-18	-30	-11	-34	-36	-15	-12	-28
Duluth,	11	-21	-14	-26	-29	-25	-33	-29	-37	-39	-12	-18	-22
Keokuk,	26	-16	-16	-8	-22	-26	-27	-25	-32	-43	-30	-16	-37
La Crosse,	17	-25	-13	-17	-26	-28	-40	-29	-39	-44	-21	-11	-34
Vicksburg,	49	+8	-11	-6	-7	-9	-17	-29	-7	-21	-27	-23	-37
Davenport,	23	-11	-16	-10	-21	-19	-27	-27	-30	-40	-23	-12	-28
St. Louis,	31	-8	-16	-5	-11	-21	-24	-34	-23	-45	-34	-22	-29
Memphis,	39	-6	-12	-6	-9	-14	-19	-29	-13	-34	-28	-19	-29
New Orleans,	55	+3	0	+10	+2	-2	-13	-24	9	+2	-15	-21	-32
Cairo,	35	-9	-16	-7	-7	-20	-18	-37	-13	-39	-29	-24	-27
Mobile,	51	+5	+1	+8	+3	+1	-17	-24	-9	-1	-13	-13	-33
Milwaukee,	21	-7	-14	-9	-24	-17	-31	-33	-34	-42	-17	-4	-6
Chicago,	24	-5	-15	-1	-25	-12	-24	-34	-32	-44	-17	-6	-20
Marquette,	18	-17	-15	-21	-27	-12	-36	-38	-28	-32	-15	-5	-5
Escanaba,	16	-10	-16	-18	-26	-12	-36	-24	-34	-36	-16	-8	-4
Nashville,	39	+4	-9	0	-6	-6	-18	-36	-14	-31	-19	-12	-27
Montgomery,	48	+7	+4	+15	+2	+2	-16	-27	-13	-3	-6	-10	-28
Grand Haven,	26	+6	-5	-7	-21	-11	-19	-30	-28	-36	-26	-16	-6
Indianapolis,	30	-6	-19	-5	-12	-7	-27	-39	-23	-41	-32	-17	-22
Louisville,	35	-3	-13	-2	-6	-7	-19	-29	-12	-35	-25	-15	-28
Cincinnati,	34	-1	-14	-6	-6	-4	-17	-36	-12	-33	-31	-15	-26
Knoxville,	38	+2	-3	+2	-3	+9	-11	-34	-19	-10	-10	-5	-24
Toledo,	28	-9	-15	-4	-15	-7	-23	-43	-19	-37	-22	-20	-23
Alpena,	23	-10	-14	-11	-18	-1	-17	-36	-25	-33	-18	-18	-10
Detroit,	26	-7	-13	-3	-9	-4	-19	....	-15	-39	-19	-18	-20
Lake City,	62	-4	+3	+11	+12	+16	0	-20	-19	-4	+4	-9	-24
Punta Rassa,	66	-3	-2	+1	0	+3	-4	-13	-10	-3	+2	+1	-6
Augusta,	46	0	+6	+6	+2	+1	-7	-20	-23	-7	-16	-16	-22
Key West,	70	-3	+1	+2	+2	+4	-4	-6	-3	-2	+4	+3	-3
Jacksonville,	[illegible]	-7	-1	+7	+6	+12	0	-17	-17	-7	+2	-10	-22
Cleveland,	28	-6	-11	-2	-5	+4	-16	-40	-13	-29	-24	-13	-23
Saugeen,	28	-4	+9	-10	-12	-6	-12	-27	-20	-24	-27	-24	-28
Port Stanley,	28	-12	-15	-7	-19	-3	-20	-44	-16	-37	-23	-22	-22
Savannah,	50	-4	+9	+13	+3	+11	-1	-20	-11	-8	-4	-18	-25
Port Dover,	28	-11	-14	-6	-15	-3	-21	-41	-15	-37	-26	-21	-27

Table—continued.

STATIONS.	Mean temp. of Dec.	ABOVE OR BELOW THE MEAN TEMPERATURE.											
		Dec. 16.	Dec. 17.	Dec. 18.	Dec. 19.	Dec. 20.	Dec. 21.	Dec. 22.	Dec. 23.	Dec. 24.	Dec. 25.	Dec. 26.	Dec 27.
Charleston,	49°	— 1	+ 9	+ 2	+ 1	+ 11	+ 1	—16	—12	— 4	—17	—16	—18
Pittsburg,	31	— 3	—13	— 5	—10	+14	—12	—36	—11	—30	—26	— 9	—22
Toronto,	23	— 8	—10	— 2	— 9	+ 9	—13	—33	—12	—28	—24	—24	—25
Lynchburg,	36	0	+ 2	— 4	— 4	— 3	— 8	—26	—16	—18	—26	—18	—21
Buffalo,	29	— 2	— 5	— 6	— 7	+ 9	—11	—30	—12	—27	—23	—14	—17
Wilmington,	46	0	....	— 3	— 3	+11	— 2	—15	—25	— 8	—19	—12	—12
Rochester,	25	— 3	— 6	— 9	+ 1	+11	—14	—32	—12	—24	—24	—22	—21
Washington,	35	— 2	— 3	— 5	— 7	+ 2	—10	—31	— 7	—27	—27	—20	—23
Baltimore,	35	— 1	0	— 4	— 1	+ 1	— 6	—27	— 7	—24	—21	—18	—20
Oswego,	28	— 4	— 2	— 6	— 1	+ 4	— 6	—20	—14	—20	—28	—21	—23
Kingston,	21	— 1	— 3	+ 4	— 4	0	— 6	—28	— 5	—38	—42	....	—27
Norfolk,	40	— 2	+ 1	0	— 5	+18	— 7	—17	—11	—18	—19	— 4	—19
Philadelphia,	33	— 3	— 2	— 3	— 2	+ 7	— 6	—27	— 9	—22	—28	—24	—24
Cape May,	34	+ 7	— 2	+ 2	— 4	+10	— 7	—22	— 4	—23	—22	— 3	—22
New York,	32	— 2	— 1	— 1	— 2	+ 6	— 3	—18	—14	—21	—24	—24	—20
Montreal,	16	+ 1	+ 5	+ 4	— 2	+ 3	— 3	— 9	—12	—26	—32	—29	—16
Burlington,	22	4	+ 5	— 6	— 1	+ 3	+ 1	—14	—18	—28	—36	—34	—24
New London,	29	— 7	— 1	— 7	— 5	+ 8	— 1	—15	— 8	—20	—26	—25	—21
Mt. Washington,	6	+ 1	+ 4	+ 1	— 6	— 1	— 4	— 5	—10	—25	—25	—10	+ 2
Quebec,	14	—11	+ 5	— 4	— 9	— 2	— 6	+ 1	—21	—28	—36	—34	—18
Boston,	28	— 7	— 1	— 5	— 2	+ 6	+ 3	— 9	—19	—19	—32	—26	—17
Portland, Me.,	23	—11	— 5	— 9	+ 1	+ 6	0	— 4	—19	—21	—40	—26	—12
Halifax,	26	— 9	— 1	—17	— 1	—11	+ 9	— 6	—17	—16	—30	—23	— 2

It will be observed that at the stations on the Pacific coast the depression was at no time greater than 12°; and at Corinne the only other station west of the Rocky Mountains the greatest depression was 22°. Hence it is obvious that the extreme cold experienced in Dakota *did not come from beyond the Rocky Mountains;* certainly not from any point south of lat. 49°. During the period in question, intense cold uniformly made its first appearance on the east side of the Rocky Mountains near long. 100° It cannot be certainly decided from the observations, in what latitude the depression of the thermometer below the mean was greatest. The greatest observed depression was not always at the most northern station, which seems to indicate that there was a source of cold independent of the transfer of air from a higher to a lower latitude. When a cold area was once formed, it exhibited remarkable persistence both as respects its form and position. In its motion southward, it followed closely the eastern slope of the Rocky Mountains, and at one time a depression of 32° extended entirely across the United States from Canada to the Gulf of Mexico at Indianola; but at Charleston and Norfolk on the Atlantic coast the greatest depression was 24°; and generally at the eastern stations the

greatest depression was less than at western stations in the same latitude.

These results appear to explain the facts mentioned in my third paper (vol. x, p. 11) showing that a great diurnal change of temperature is most common at stations near the eastern slope of the Rocky Mountains. The cold wave makes its first appearance in this region and the intensity of the cold is sensibly diminished as the wave travels eastward. An example illustrating the variable climate of the eastern slope of the Rocky Mountains occurred Dec. 24, 1872. Denver was at that time on the borders of the cold area which prevailed from the Rocky Mountains to Nova Scotia, and during the night of the 23d and 24th the thermometer fell to 2°. During the 24th, Denver began to feel the influence of the storm which was advancing from Oregon, and on that day the thermometer rose to 55°, showing a change of 53° in a day, and probably the entire change took place in less than 24 hours. Similar cases must frequently occur near the eastern slope of the Rocky Mountains, and the changes of temperature are more sudden here than they are near the Atlantic coast, because the cold which succeeds a storm is more intense than it is in the eastern portions of the United States.

It will be noticed that from Dec. 23d to Dec. 27th, the depression of temperature on the summit of Mt. Washington (elevation 6,285 feet) was generally less than at other stations in its vicinity. On the 24th, the depression on the summit was about the same as near its base; but on the 26th the depression was *twenty degrees less* than near the base, indicating that at this time the vertical thickness of the cold stratum of air did not much exceed 9.000 feet.

The fluctuations of temperature observed from Dec. 16 to Dec. 27, 1872, were similar in their general features to those occurring every winter, but they were remarkable for the long continuance of an unusually low temperature. What was the cause of this protracted period of severe cold? It can scarcely be doubted that this low temperature was, at least, in part, due to causes in operation beyond the limits of the United States. It is noticeable that during this period the barometer was unusually high, and there was a general correspondence between the curves of high pressure and of low temperature. If then we can discover the cause of the high barometer, we shall probably find the explanation of the low temperature.

In my third paper (vol. x, p. 8) I gave a table showing the number of cases in which an area of high pressure was found on different sides of an area of low pressure during a period of three years. These numbers are as follows:

On the North side,	23 cases.		On the South side,	25 cases.	
" Northeast "	39	"	" Southwest "	20	"
" East "	90	"	" West "	37	"
" Southeast "	75	"	" Northwest "	19	"

It will be observed that an area of high barometer was found on the east side of an area of low barometer almost three times as frequently as on the west side; and it was found on the southeast side almost four times as frequently as on the southwest side. These numbers are to be understood as applying to the United States Weather Maps: that is, the centers of high and low pressure were restricted to a certain distance from each other, and the average distance was about 1200 miles. The prevalent direction is about 20° south of east; in other words, whenever an area of low barometer is formed in the United States, we may be tolerably sure that there exists at the same time an area of high barometer at a distance of about 1200 miles, and in a direction a little south of east.

In order to determine whether this coincidence was the result of local causes, I have examined Hoffmeyer's charts for the Atlantic Ocean and Europe and have found that an area of low barometer on the northern part of a chart, is almost invariably accompanied by an area of high barometer on the southern part of the same chart. In about three-fourths of the cases examined, the direction of the high pressure from the low is southeast, and the average distance is about 1700 miles. These results are derived from so large a number of cases that they cannot well be ascribed to accident, and seem to indicate the operation of a general law. They naturally suggest the idea that areas of high pressure are formed from the air which is expelled from areas of low pressure; and that in Europe as well as in the United States this forming process takes place chiefly on the southeast side of an area of low pressure. The comparisons which I have made also indicate that in Europe the direction of the high area from the low area is more southerly than it is in the United States, and the distance sensibly greater.

These conclusions may be tested in another way. Low barometer is generally associated with high temperature, and high barometer with low temperature. Hence we should conclude that a temperature above the mean in Iceland, would be accompanied by a temperature below the mean in Central Europe. For the purpose of comparison, I have taken the tables furnished by Prof. Dove in the Memoirs of the Berlin Academy. He has there given the mean temperature of Iceland for each month from 1823 to 1837, a period of fifteen years, and also the mean temperature of numerous stations in Europe for the same period. I selected all those months in which the

temperature at Iceland was at least one degree (Reaumur) above the mean, and placed opposite them in a table, the temperature of the corresponding months at Vienna, Berlin, Prague and numerous other stations scattered all over Europe. The number of months employed in this comparison was 50, and during this period the average temperature at Iceland was 2°·10 R. *above* the mean for the corresponding months. During the same months the temperature at Vienna was 0°·94 R. *below* the mean, showing between the two places a variation from the mean temperature amounting to 3°·04 R. or 6°·84 Fahr. If we restrict the comparison to the four months from November to February, the difference amounts to 8°·66 Fahr.

I then selected all those months in which the temperature of Vienna was at least one degree (Reaumur) *below* the mean and placed opposite to them the temperature at Iceland for the same period, and found that during the four coldest months of the year the result was of the same kind and quite as decided as in the former comparison; but during the warmer months the influence was less noticeable.

Similar differences, but not quite as great, were found to prevail throughout Austria and Germany, and the same influence in a diminished degree prevails in France, Italy and a large part of Russia. The period employed in this comparison seems to be long enough to establish a law, and I think we must conclude that when the temperature of Iceland is much *above* the mean, the temperature of Central Europe is generally depressed *below* the mean, and this influence is most decided during the colder months of the year.

The results thus obtained for the United States and for Europe suggest the idea that an area of unusually high barometer in the central portion of North America may be the result of a storm prevailing at a distance of 1500 or 2000 miles in a northwest direction. Upon referring to a map we find that the Aleutian Islands are situated in this direction, and at a distance of about 2000 miles from Oregon, and we know that in the neighborhood of these Islands the storms of winter are unusually severe and the barometer often sinks extremely low. If we had maps showing the isobaric curves from day to day in the vicinity of the Aleutian Islands, and extending to the central portions of North America, it is presumed we should find that low pressure near these Islands was generally attended by an area of high pressure in a southeast direction at a distance of 1500 or 2000 miles. The Report of the United States Signal Service for 1873 contains Meteorological observations at St. Paul's Island, lat. 57° N., long. 170° W., but I have no observations from the interior of British America suitable for comparison with them; it is, however, remarkable that in several cases

in 1872–3, when the barometer was unusually low at St. Paul, it was unusually high in Oregon or Dakota. The following is an example:

DATE.	St. Paul.	Portland, Oregon.
1872, Nov. 13	29·92	30·52
" 14	29·40	30·55
" 15	29·07	30·60
" 16	29·08	30·51
" 17	29·43	30·52
" 18	28·68	30·64
" 19	28·62	30·58
" 20	28·98	30·56
" 21	29·38	30·40

During this period of nine days while the average pressure at St. Paul was 29·20, the average pressure at Portland, Oregon, was 30·50. Also from Dec. 15 to 26, 1872, the average pressure at Breckenridge, Minnesota, was 30·50, but during the same time the average pressure at St. Paul was 29·25; and Dec. 18, when the barometer at Breckenridge stood at 30·70, the barometer at St. Paul stood at 28·05.

Form of areas of maximum and minimum pressure.

In preceding articles (this Jour., vol. viii, p. 11, and vol. x, p. 9) I have shown the average form of the isobars about a storm center as derived from observations of three years. I have since made a similar comparison of observations of three years (1873–5) to determine the form of the isobars about an area of maximum pressure. The isobar selected has generally been that of 30·20; but when the observations were insufficient to show the complete form of this curve, I have taken the isobar 30·30, provided that curve was nearly complete. When both of these curves were incomplete I have taken the next highest curve whose form could be satisfactorily determined. The whole number of cases employed in these comparisons was 238. The longer axis of each of these isobars was measured, and also the axis perpendicular to the former, and the ratio of the two was determined. The average ratio of the two axes was found to be 1·91. In fifteen cases the major axis was at least three times the minor axis; and in two cases the major axis was at least four times the minor axis; the highest value being 4·6. In other words, the average form of the isobars about an area of maximum pressure is an oval whose major axis is nearly double the minor axis; and in six per cent of the cases the major axis is three times the minor axis, while in one per cent of the cases the major axis is four times the minor axis.

The average ratio of the two axes of the isobars about an area of minimum pressure was found to be 1·94; and in nearly four per cent of the cases the major axis was four times the minor axis.

The direction of the major axis of each curve was measured with a protractor, and reckoned in degrees from the north point toward the east. The following table shows the number of cases included in each interval of ten degrees. Column first shows the directions divided into intervals of ten degrees, and column second shows the number of cases occurring in each interval. In order to eliminate the influence of accidental causes, I have taken the average of each three successive numbers in column 2d, and have placed the result in column 3d. These numbers show a decided maximum corresponding to the direction N. 44° E. Column 4th shows the observations of the isobars about an area of minimum pressure as heretofore reported, and column 5th shows the averages of the same numbers taken in sets of three. These numbers also show a decided maximum corresponding to the direction N. 39° E.

The close agreement between the average form of the curves for high and low pressure, as well as in the prevalent direction of the major axis of the curve seems to indicate the operation of a constant cause. In order to determine whether this phenomenon is of a local nature, I have made a similar comparison of European observations. I took Hoffmeyer's charts from Dec., 1873, to Nov., 1874 and measured the form of the isobars about each storm center.

Position of the Major Axis of the Isobars.

DIRECTIONS.	UNITED STATES.				EUROPE.			
	High Barom.		Low Barom.		Low Barom.		High Barom.	
	Cases.	Aver.	Cases.	Aver.	Cases.	Aver.	Cases.	Aver.
0°– 10°	19	15	17	12	7	5	2	3
10 – 20	12	15	18	17	8	6	3	2
20 – 30	14	17	15	22	4	6	2	2
30 – 40	25	20	34	24	6	6	1	1
40 – 50	21	25	23	26	7	7	1	1
50 – 60	29	22	22	17	7	6	2	3
60 – 70	17	17	7	15	4	5	7	5
70 – 80	8	12	16	10	4	3	5	6
80 – 90	11	7	8	13	1	2	5	4
90 –100	3	5	14	10	1	1	2	4
100 –110	2	3	9	10	1	2	5	3
110 –120	5	4	7	6	3	2	3	4
120 –130	6	5	3	6	3	4	5	3
130 –140	5	7	7	6	5	4	1	3
140 –150	9	7	8	8	3	3	2	1
150 –160	6	8	8	8	2	2	1	1
160 –170	9	10	8	9	1	2	1	2
170 –180	14	15	10	12	3	4	3	2

Only those cases were selected which contained an isobar as low as 740 millimeters. The isobar selected for measurement was seldom the lowest isobar drawn on the maps, but the largest isobar which was complete (or nearly so) about the storm center. The number of cases employed was 70, and the average ratio of the two axes was 1·60. Column 6th in the preceding table shows the number of cases for each 10° of azimuth ; and column 7th shows the averages of the same numbers taken in sets of three.

In a similar manner the isobars about areas of maximum pressure were measured. Only those cases were selected which contained an isobar as high as 775 millimeters, and frequently this was the isobar selected for measurement ; but if the map showed a larger isobar which was complete, or nearly so, that was taken in preference. The number of cases employed was 51 and the average ratio of the two axes was 1·82. In the preceding table, column 8th shows the number of cases for each 10° of azimuth, and column 9th shows the averages of the same numbers taken in sets of three.

The following table presents a summary of the preceding results both for low and high pressures in the United States and Europe.

Summary of Results for Isobars.

	LOW BAROMETER.		HIGH BAROMETER.	
	United States.	Europe.	United States.	Europe.
Ratio of the two axes,	1·94	1·60	1·91	1·82
Prevalent direct. of major axis,	N. 39° E.	N. 31° E.	N. 44° E.	N. 76° E.

This table suggests some obvious reflections, but I prefer to withhold them until I have obtained a longer series of observations from Europe.

Relation of rainfall to variations of barometric pressure.

In former articles (this Jour., vol. viii, p. 4 and vol. x, p. 5) I have shown a close connection between the rain-fall and the direction and velocity of a storm's progress. I have also endeavored to determine (vol. viii, p. 11) by what indications it may be known whether the barometric pressure at the center of a storm is increasing or diminishing. Since receiving the published observations of the Signal Service for eleven months (Sept., 1872 to July, 1873) I have resumed this discussion and have discovered a decided connection between the amount of rain-fall and the pressure at the center of the storm. For the purpose of comparison, storms were divided into three classes ; one class including those cases in which the barometric depression at the center of the storm was the same on two successive

days, or the change was less than 0·05 inch. A second class included those cases in which the pressure at the center *decreased* to the extent of at least 0·05 inch; and a third class included those cases in which the pressure *increased* to the extent of at least 0·05 inch. The following is the result of this comparison including 194 cases for eleven months of observations.

Influence of variations of barometric pressure.

	No. of cases.	Barom. at centre.	Variation in 24 hours.	AMOUNT OF RAIN-FALL. Within isobar 29·90.	Within isobar 29·80.	Greatest fall.
Pressure increasing,	45	29·58	+·100	·069	·078	0·65
" stationary,	81	29·56	—·005	·120	·149	0·86
" decreasing,	68	29·48	—·128	·134	·159	1·02

Column 2d shows the number of cases of each of the three classes of storms investigated; column 3d shows the average pressure at the center of the storms under investigation; column 4th shows the average change of pressure at the center of the storm in twenty-four hours, + increasing, – diminishing; column 5th shows the average rain-fall for eight hours at all the stations included within the isobar 29·90; column 6th shows the average rain-fall at the stations within the isobar 29·80; and column 7th shows the average obtained by taking the greatest rain-fall reported for each storm at any of the stations. This greatest rain-fall generally occurred near the center of the storm-area.

These results clearly indicate that the amount of rain-fall is least when the pressure at the center of the storm is increasing, or the storm is diminishing in intensity; and the amount of rainfall is greatest when the pressure at the center of the storm is decreasing, or the storm is increasing in intensity; and we arrive at the same conclusions whether we take the average rain-fall at all the stations within the isobar 29·90; or confine ourselves to the stations within the isobar 29·80; or take simply the single station which reports the greatest rain-fall. This effect is most decided during the colder months of the year.

Stationary storms near the coast of Newfoundland.

In a former article (vol. xi, p. 17) I have noticed the fact that storms sometimes remain almost stationary for several days near Nova Scotia or Newfoundland. This phenomenon I ascribe to an unusual precipitation of vapor in that vicinity. The vapor is furnished by the warm water of the Gulf Stream, and the high-lands near the coast afford facilities for its precipitation. We should therefore expect to find the average rainfall in this vicinity to be unusually great. That such is the fact is shown by the following table which gives the annual

rain-fall at various stations along that part of the coast. For this table I am indebted to Mr. G. T. Kingston, Superintendent of the Meteorological Service of Canada.

Annual Rain-fall in Nova Scotia and its vicinity.

STATIONS.	Latitude.	Longitude.	Average rain-fall. Inches.	No. of years.
St. Johns,	47° 33′	52° 40′	55·86	4
Harbor Grace,	47 42	53 15	48·36	4
Bay St. George,	48 30	58 29	47·75	1
Glace Bay,	46 13	59 58	61·81	6
Sydney,	46 12	60 14	58·36	6
Cape North,	47 3	60 25	47·35	1
Port Hastings,	45 39	61 29	43·67	2
Guysborough,	45 23	61 36	60·40	3
Pictou,	45 42	62 40	50·58	2
Charlottetown,	46 14	63 10	41·90	3
Truro,	45 20	63 20	49·50	4
Seaforth,	44 38	63 34	47·87	2
Halifax,	44 40	63 36	51·29	11
Beaver Bank,	44 34	63 39	42·94	3
Windsor,	44 54	64 7	42·53	1
Dorchester,	45 46	64 18	48·53	4
Cape Rozier,	48 56	64 21	33·17	3
Wolfville,	45 5	64 25	41·88	8
Bass River,	46 30	65 12	38·21	5
Chatham,	47 1	65 30	44·48	2
Bathurst,	47 37	65 41	33·21	2
St. John,	45 14	66 5	54·68	·9
Fredericton,	45 55	66 40	45·52	4
Quebec,	46 48	71 12	37·27	6

It will be noticed that near the southern coast of Nova Scotia and Newfoundland there is a line of stations where the annual rain-fall ranges from 50 to 60 inches, while at a distance of 200 or 300 miles from the coast, the annual rain-fall is less than 40 inches. Also if we follow along the coast of the United States as far south as Washington we find that scarcely any where does the average rain-fall exceed 45 inches. The precipitation on the south coast of Nova Scotia and Newfoundland is therefore excessive, and is sometimes sufficient to hold a storm nearly stationary for several days.

Course and velocity of storms in tropical regions.

In order to discover the causes of the movement of storm-areas, it is important to study their phenomena under the greatest possible variety of circumstances. For this purpose I have prepared a list of all the storms originating near the West India Islands, for which I have found definite paths assigned by any investigator. The principal results are exhibited in the following table. Column 1st shows the date of commencement of the storm so far as ascertained; column 2nd shows

the latitude of the storm's center when it first became violent; column 3d shows the average course of the storm while moving westward; column 4th shows the hourly velocity of progress in the preceding part of its course; column 5th shows the latitude at which the storm was moving due north; column 6th shows the average course of the storm after turning eastward until it reached the parallel of 40°; column 7th shows the hourly velocity of progress during the preceding period; column 8th shows whether rain was mentioned as accompanying the storm; column 9th indicates the name of the person by whom the phenomena of the storm were investigated; (R) stands for William Reid; (W) stands for William C. Redfield; (M) for Matthew F. Maury; (B) for Alexander Buchan; (E) for John R. Eastman; (T) for Henry Toynbee; and (S) for the U. S. Signal Service. Column 10th shows where the record of the investigation may be found.

It will be noticed that the least latitude of any storm-path here recorded is 10°; that is, over the Atlantic Ocean no storm-path has been traced within 10° of the equator. On Maury's storm chart for the North Atlantic (this Jour., vol. xi, p. 12) among 6436 observations, each observation representing a period of eight hours, four gales are reported within five degrees of the equator. Also between 5° and 10° north latitude, among 6476 observations, eight gales are reported. On Maury's chart for the eastern half of the North Pacific Ocean, among 17,854 observations, 35 gales are reported between the equator and 5° N. latitude; and between 5° and 10° N. lat. among 9352 observations, 33 gales are reported. Storms do therefore sometimes occur almost directly under the equator, but on an average only once or twice a year.

The courses of the storms mentioned in the preceding table range from 11½° south of west to 62° north of west. In two cases the course was south of west; in a third case the course was only one degree north of west, and in a fourth case the course was only 5° north of west. Tropical storms do therefore sometimes travel towards the equator; and it is probable that this direction occurs more frequently than the table would indicate, since many of the storms here recorded would never have been selected for investigation, if they had not advanced into the middle latitudes. The average course of the storms here mentioned while moving westward was west 24° north; and the average hourly velocity in this part of their course was 17·4 miles.

The average latitude of the storm's center when moving due north was 29½ degrees, and the latitudes range from 23½ to 34 degrees. During the three summer months the average latitude is 30°·6; in September it is 29°·7, and during the other months of the year 26°·7, indicating that the point where the course changes from west to east is more northerly in summer

than in winter. The average course of these storms while traveling eastward to the parallel of 40° was E. 38½° N. ranging from 17° to 60°. The average hourly velocity in this part of their course is 20·5 miles, which is almost exactly the average velocity of storms in the United States for the months of August and September according to the Signal Service observations.

Course of Hurricanes originating near the West India Islands.

Date of Storm.	Latitude of beginning.	Course while moving Westward	Velocity in miles per hour.	Latitude when moving North.	Course while moving Eastward.	Velocity in miles per hour.	Rain-fall.	Investigator.	Where Recorded.
1780. Oct. 3.	16·5°				E. 61·5° N.		*Rain.*	[illegible]	Law of Sts., p. 273.
1780. Oct. 12	11·8	W. 31° N.	17·8	23 3°	E. 39·5 N.	17·2	*Rain.*	R	Law of Sts., p. 273.
1804. Sept. 3.	15·7	W. 30 N	20·4	31·2	E. 46 N.	18 1	Rain.	W	J. S., v. 20, p. 17.
1821. Sept. 1.	21·7	W. 27 N.	35·0	31·2	E. 55 N.	25·0	*Rain.*	W	J. S., v. 20, p. 17.
1827. Aug. 17	14·8	W. 29 N.	12·9	30·0	E. 43 N.	10·0	*Rain.*	W	J. S., v. 31, p. 123.
1830. Aug. 12.	17·3	W. 23 5 N.	23·8	31 4	E. 37 N.	16·3	Rain.	W	J. S., v. 20, p. 34.
1830. Aug. 22.	22·3	W. 27 N	18·7	30·3	E. 40 N.	16·0	Rain.	W	J. S., v. 20, p. 39.
1830. Sept. 29.	20·2	W. 33·5 N.	26·4	30·4	E. 43 N.	29·6		W	J. S., v. 20, p. 42.
1831. Jan. 13.	30·0			30·0	E. 53·5 N.	16·6	Snow.	W	U.S. N. Mag. 1836.
1831. June 23.	10·3	W. 14·5 N.	20·4					W	J. S., v. 31, p. 123.
1831. Aug. 10.	12·3	W. 25·5 N.	16·6	30·7			*Rain.*	W	J. S., v. 21, p. 192.
1835. Aug. 12.	16·3	W. 17 N.	17·8				Rain.	W	J S., v. 31, p. 124.
1835. Sept. 3.	12·4	W. 38 N.					*Rain.*	R	Law of Sts., p. 36.
1837. July 26.	11 0	W. 29 N.		30·0			Rain.	R	Law of Sts., p. 48.
1837. Aug 2.	17·3	W. 31·5 N.					*Rain.*	R	Law of Sts., p. 49.
1837. Aug. 12.	17·6	W. 20 N.		31·7	E. 24·5 N.		Rain.	R	Law of Sts., p. 69.
1837. Aug. 24.	32 7				E. 47 N.	17·5	*Rain.*	R	Law of Sts., p. 109.
1837. Sept. 27.	15 7	W. 24 N.	8·3	26 2	E. 17·5 N.	13·4	*Rain.*	R	Progress, p. 13.
1839. Sept. 12.	18 5	W. 26 N.		32·2			*Rain.*	R	Progress, p. 39.
1842. Aug. 30	21·6	W. 1 N.	10·0				Rain.	W	J. S., v. 1, p. 2.
1842. Oct. 2.	20·0				E. 18 N.	10·6	*Rain.*	W	J. S., v. 1, p. 163.
1844. Oct. 4.	18 6				E. 54 N.	30 4	*Rain.*	W	J. S., v. 2, p. 312.
1846. Sept. 11.	13·8	W. 62 N.	10·3	29·2	E. 47 N.	14·3	*Rain.*	W	J. S., v. 18, chart.
1846. Oct. 6.	14·2	W. 60 N.		30·0	E. 60·5 N.	23 5	Rain.	W	J. S., v. 18, chart.
1847. Oct. 10.	12·8	W 11·5 S.	21·2				Rain.	R	Progress, chart.
1848. Aug. 22.	15·0	W. 28 5 N.		27·4	E. 22 N.			R	Progress, p. 337.
1848. Aug. 29.	15·0	W. 22 N.		29·0	E. 24 N.		*Rain.*	M	Phys. Geog., p. 60.
1850. Sept. 2	16·0	W. 5 N.	13·8					W	J. S., v. 18, p. 176.
1851. Aug. 16.	13·5	W. 15 N.	17·6	27·3	E. 34 N.	18·7	Rain.	W	J. S., v. 18, chart.
1853. Aug. 30.	12·5	W. 12·5 N.	25·3	31·7	E. 24·5 N.	28·4	Rain	W	J. S., v. 18, p. 1.
1853. Sept. 26.	28·8			29·2	E. 27 N.		Rain.	W	J. S., v 18, p. 180.
1853. Sept. 29.	13·9	W. 9 N.					*Rain.*	W	J. S., v. 18, p. 178.
1866. Oct. 1.	19 0	W. 15 N.	15·0	26·4	E. 25 N.	30·0	Rain.	B	Han. Book, p. 151.
1867. Oct. 29.	18·5	W. 2 S.	15 5				Rain.	E	Pamphlet.
1871. June 1.	23·5	W. 14 N.	12·3	31·5	E. 45 N.	23·5	Rain.	S	Rep. 1872, p. 282.
1871. Sept. 5.					E. 38 N.	15·0	Rain.	S	Rep. 1874. Map.
1873. Aug. 18.	20·0	W. 32 N.	12·3	33·0	E. 37 N.	18·4	Rain.	S	Rep. 1873, p. 1029.
1873. Aug 20.	25·0	W. 51 N.	10·5	34·3	E. 41 N.	16·4	Rain.	T	Met. Soc., v. 2, p. 15.
1873. Oct. 6.	21·3	W. 28 N.	9·5	24·3	E. 45 N.	30 1	*Rain.*	S	Monthly Map, '73.
1874. Feb. 7.	24·0			26 5	E. 45 N.	23·5	Rain.	S	Rep. 1874. Map.
1876. Sept. 14.	23·0	W. 22 N.	25·1	28·5	E. 24 N.	29·6	*Rain.*	S	Monthly Map.

In column 8th the word rain when italicized signifies *hard rain*; when in capitals it signifies VERY HARD RAIN, or rain descending in TORRENTS. It will be perceived that rain generally accompanies hurricanes. In four of the cases I find in the published reports no mention of rain, but it is presumed that this is simply an oversight, since in most of the other cases rain is only incidentally mentioned. In all the investigations of Redfield and Reid the circumstances upon which they insist as specially important are the direction and force of the wind; and it is only by consulting the extracts from the log-books which they have furnished us, that I have discovered any mention of accompanying rain. It is believed that tropical hurricanes *never* occur without rain. and generally the rain is described as descending in *torrents*.

Further remarks upon the preceding table are reserved for a future article. In preparing the materials for this article, I have been assisted by Mr. Edward S. Cowles, a graduate of Yale College of the class of 1873.

ART. II.—*The Colorado Plateau Province as a Field for Geological Study*; by G. K. GILBERT.

I. *Definition and Description of the Province.*

IN the Mississippi Valley and "the Plains" the strata are almost undisturbed and lie nearly level. They have, indeed, been lifted above the parent ocean, and in part raised to a height of thousands of feet, but broad areas have moved together and all flexures have been gentle. There are no traces of the foldings which characterize the Appalachian region. The prevalent features of topography are plains and hills.

From the western edge of the Plains to the Pacific Ocean the characteristic features are mountains. The strata are bent and broken, and upturned at all angles. The typical structures are structures of displacement. Within this region of great disturbance is a restricted area of comparative calm. Dislocations of strata are not unknown in it; indeed, they are of frequent occurrence; but they are less frequent, less profound, and less complex, than in the surrounding region of mountains. Its mountains are few and scattered, and its typical topographic form is the table or plateau. It is called the Colorado Plateau province.

This region of plateaus was crossed by many lines of early exploration, and the salient features of its topography were described by numerous observers. The first writer who called attention to the extent of the district, and colligated the north-

ern portions with the southern, was Professor W. P. Blake (Pac. R. R. Repts., vol. iii, part IV, pp. 8 and 42, 1856.) The title of "Colorado Plateau" first appeared in the map of Ives' Colorado River Report in 1861, and was written between San Francisco mountains and the Grand Cañon. Later usage extended the term to include the broad upland through which the Colorado has excavated its deep channel; and finally, as the minor plateaus of which the great one is composed began, in the progress of geographical knowledge, to be discriminated and named, the comprehensive title of the whole became *the Colorado Plateaus* or *the Colorado Plateau Province.* Portions of the region have been studied, described, and mapped by numerous geologists and geographers, but the chief contributions to our knowledge of the Province as a whole, and of its limits, have come from the surveys conducted by Major Powell and Lieutenant Wheeler.*

It would avail little to describe in detail the boundaries of the province without the aid of a map. On the east it is separated from the Plains by a continuous broad belt of mountains, which include the parks of Colorado and have been called the Park Mountain System. On the south and west it adjoins the Basin Range Province, a region of many short parallel ranges, separated by trough-shaped, desert valleys. Northward it is limited by mountains for which there is no comprehensive title. Its greatest extent from north to south is 700 miles; from east to west, 425 miles. It comprises, of southern Wyoming, 20,000 square miles; of eastern Utah, 50,000; of western Colorado, 30,000; of northeastern Arizona, 45,000; and of northwestern New Mexico 25,000;† making a total of 170,000 square miles, or one-twenty-fourth part of the territory of the United States. It is drained chiefly by the Colorado of the West and its tributaries, but the Sevier river heads in the western margin, and the Puerco of the East in its eastern, and the North Platte drains its northeastern angle. The plateaus which compose it range in altitude from 5,000 to 11,000 feet above the sea, but the lines of drainage are much lower, and the streams run at the bottoms of deep gorges or cañons. The plateaus are terminated in part by cliffs, and the cañon walls are cliffs. Plateaus, cañons, and cliffs are the characteristic features. The chief mountains are of volcanic origin, and they are doubly conspicuous, since

* Exploration of the Colorado River of the West and its tributaries; by J. W. Powell. Washington, 1875.

U. S. Engineer Explorations and Surveys west of the 100th meridian, vol. iii, Geology; by G. K. Gilbert, Archibald R. Marvine, Edwin E. Howell, and J. J. Stevenson. Washington, 1876.

† In defining the province in my report to Lieut. Wheeler (see U. S. Eng. Expl. and Sur. W. of the 100th mer., vol. iii, Geology, pp. 43 and 542) I have not included the portion south of the Uinta mountains. I was not aware, at the time of writing, that the plateaus south of the Uintas were continuous with those of Wyoming, the Uinta uplift not extending eastward to the Park Mountains.

they not only constitute some of the loftiest points, but are exceptional to the general character of the topography.

The climate is extremely dry—so dry that agriculture is impossible without irrigation. Vegetation is scant, except upon the heights. Below 8,000 feet altitude it is too sparse to interfere with the examinations of the geologist, and there are vast stretches of absolutely naked rock. Travel is greatly obstructed, except along certain lines, by deep cañons which ramify through the plateaus, and the selection of routes for wagon-roads and railroads is a work of great difficulty.

All this description applies more especially to the southern portions of the district. North of the Uinta mountains the streams flow in shallower and broader valleys, and are more sluggish. The Green river, the main artery of drainage, is there less deeply sunken in the plain than in its lower course, and all erosion by running water is hence less powerful. The profiles of the topography are more rounded, and accumulations of local drift and soil give rise to many grassy plains.

The only important economic mineral of the whole region is coal, and this, though unlimited in quantity, is now utilized only where the Pacific railroad affords a market. Mines of the precious metals are nearly unknown, and in default of these, which are the usual incentives to settlement in our arid territories, the region is chiefly uninhabited by whites, and portions are even unexplored, except by the ubiquitous trapper and prospector, who make no record of their discoveries. Along the western margin are Mormon settlements. The market afforded by the Pacific railroad and its dependencies, has stimulated a little farming in Wyoming, and the same result has been wrought at the south, in Arizona and New Mexico, by a line of military posts. But in the center of the province one can find a spot that is more than one hundred miles from the nearest house, excepting only the ruined and abandoned dwellings of the Pueblo Indians, who once peopled this forbidding land more densely than it is likely ever to be peopled again.

II. *How the material is exposed for study.*

As a field for the studies of the geologist, the Plateau province offers valuable *matter* in an advantageous *manner*. Let us begin with the consideration of the manner.

First, the Climate. The air is so dry that, except on the heights and at the margins of springs and streams, there is no turf, no accumulation of humus, often no soil, and so little vegetation that the view is not obstructed. From a commanding eminence one may see spread before him, like a chart, to be read almost without effort, the structure of many miles of country, and in a brief space of time may reach conclusions, which, in a

humid region, would reward only protracted and laborious observation and patient generalization. There is no need to search for exposures where everything is exposed. Dr. Newberry, speaking of one of the southern plateaus, says, "On our way to the Moqui villages we passed through a region singularly favorable for accurate geological investigation; where there is no vegetation to impede the view; where the strata are entirely undisturbed, and are cut by valleys of erosion, in the wall-like sides of which every inch of the series may be examined. In this journey we ascended in the geological scale from the summit of the Carboniferous to the base of the Cretaceous series. Of this interval there is no portion of which the exposures are not as complete as could be desired." (Geol. Ives' Exped., p. 77.)

This aridity is not peculiar to the plateaus: it pertains to the Basin Ranges, and in a less degree to the plains. But in the ranges the most arid portions are the valleys between the mountain ridges, and these are filled with monotonous Quaternary gravels and clays, which hide all other beds, while the ranges themselves, which are of more interest to the geologist, catch all the precipitation, and are in some degree clothed with verdure.

Second, the Drainage. The Plains and the Plateaus are alike drained by great rivers, which rise in lofty mountain regions, and traverse them on their way to the sea; but there the resemblance ceases. The rivers which cross the Plains flow over them in broad shallow valleys. The soft rocks of the intervening benches decay more rapidly than they are undermined, and their rounded outlines are clothed with soil. But the Colorado and its branches flow across the Plateaus in deeply carved, narrow cañons. Where the Green river, which is the main fork of the Colorado, enters the Uinta mountains, it is 2,000 feet below the adjoining plateau, and where the Colorado leaves the plateaus, it emerges from a gorge 4,000 feet deep. In the interval the current courses, almost without exception, between high cañon walls. Into this deep channel are gathered the waters of the uplands. Empowered by the rapidity of its descent, each tributary river has carved a cañon of its own, and so too has each branch and creek tributary to a river, until the whole tract is divided by a labyrinth of ramifying cañons. When the rain falls—for it does sometimes fall here—it flows down rapidly into the gorges, and washes with it the loosened particles of disintegrating rock. Then in time of flood the deepening waters, constrained to a narrow channel, rush forward with impetuous velocity and sweep out the detritus. The rocks of the upland are removed as fast as they decay, and soil cannot accumulate. Thus does thorough drainage conspire with aridity to prepare for the geologist a land of naked rock.

No less important to the student are the cañons themselves. They bear the same relation to a plain that geological cross-sections do to a geological map. They introduce in all categories of observation a third dimension, and enable the contemplation of all the phenomena of structure with reference to depth as well as length and breadth.

Third, Glacial drift and Lava-sheets. While these are, in themselves, fertile subjects of study, they are also obstructions to observation, in so far as they conceal other formations from view; and it is as obstructions that I here refer to them.

Moraines are unknown in the southern half of the Plateau province, and in the northern they are not found at a lower altitude than 7,500 feet. The few that exist pertain to what were local glaciers. There was no general ice-mantle. The southern limit of glacial phenomena is in north latitude 38° 30′, or about on the parallel of St. Louis. In the epoch of ice the climate of the Plateaus doubtless bore the same relation to that of the eastern seaboard that it does now. It was then, as now, a little colder than the latter, and a great deal drier; and it was its dryness which prevented, even at an altitude of some thousands of feet, the accumulation of such a deluge of ice as visited the Atlantic seaboard in the same latitude. Only on the highest mountains was the winter's precipitation in excess of the summer's melting.

But while the mantling by glacial drift is inconsiderable, that by extravasated material is of great extent. Some of the largest continuous lava fields of our country belong to the Plateau region. A field in southern Utah stretches ninety miles from north to south and seventy miles from east to west; and the corresponding dimensions of one in New Mexico and Arizona are one hundred and seventy-five, and one hundred and forty miles. Almost coalescent with the latter is a third field which includes the San Francisco group of peaks in Arizona. Beneath these, and beneath minor floods of lava, are buried a tenth part of the sedimentary rocks of the Plateaus.

In brief, the strata of the Plateau region are exposed with exceptional thoroughness. They are indebted to a dry climate, in ancient and modern times, for the almost entire absence of glacial drift, and for the suppression of vegetation. They are indebted to peculiar conditions of drainage for their poverty of soil, talus, and local drift, and for a system of natural cross-sections. Their chief detraction is a mere restriction of their area of exposure by overlapping lavas.

III. *The material for study.*

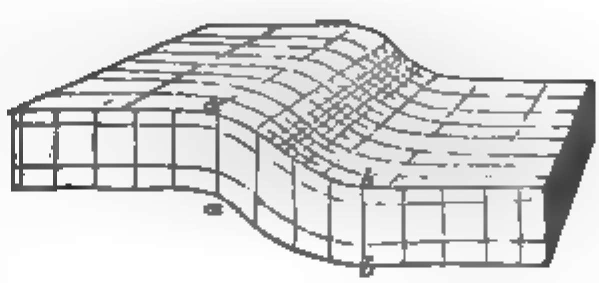
It remains to consider the nature of the material which is so fully exhibited, and examine its claims to attention. It pertains chiefly to four departments of geological investigation, viz:

Mountain building by displacement; Mountain building by eruption; Stratigraphy; and Erosion; and will be discussed under these heads, in the order indicated.*

Mountain building by di-placement. The Plateau Province differs from the mountain provinces by which it is surrounded in the degree and not in the kind of disturbance to which its sediments have been subject. Faults and folds abound through its whole extent, but they are comparatively of great simplicity. They are indeed so simple that they can be completely known. Their entire phenomena may be comprehended, measured, described, and delineated. The course of many a fault can be traced from end to end, and its throw measured at every step. The form of many a fold can be determined thoughout, and pictured or modelled in miniature, with every detail of flexure.

Now, faults and folds are the *elements* of the displacements which give rise to mountains, and to study them is to study the very rudiments of mountain structure, and to acquire a knowledge of mountain structure is to lay the indispensable geological foundation for a true theory of the origin of mountains. Hence the value of this opportunity to study the elements of displacement in an uncombined condition, and in their simplest compound forms. To enforce this proposition, which is of more importance than might at first appear, I will take an illustration from the material already gathered, and, to do so, it will be necessary to explain one or two terms that have had to be coined to describe the new group of facts.

1.



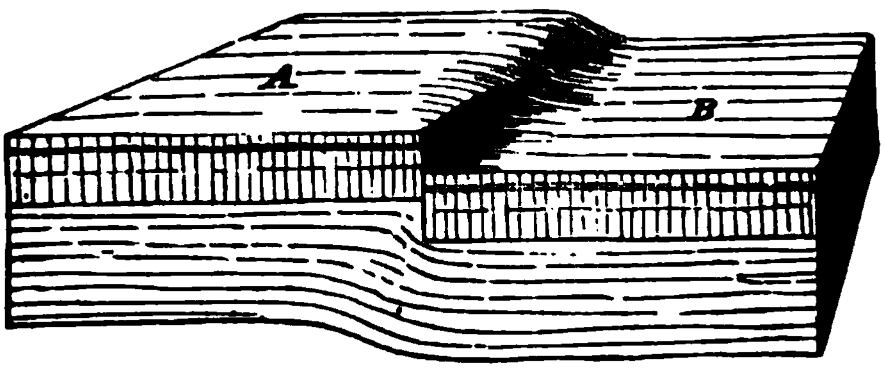
In an anticlinal fold the strata dip in two directions away from the axis. In a synclinal fold the strata dip from two directions toward the axis. There is in nature a third type, which involves a dip in only one direction. This is the *monoclinal* fold. It is a double flexure, connecting strata at one level with the same strata at another level. In figure 1, the curvature between *aa* and *bb* is a monoclinal fold.

* The writer travelled, during three summers, with field parties of the Survey in charge of Lieut. George M. Wheeler of the U. S. Engineers, and during a fourth with a field party of the Survey in charge of Major J. W. Powell. His reports to Lieut. Wheeler are published in the third volume of the reports of "Explorations and Surveys west of the 100th meridian." Besides his own observations, the chief sources from which he has derived the material here presented, are: 1. The observations of Major J. W. Powell, published in his report on the "Exploration of the Colorado River of the West and its tributaries;" and, in part unpublished. 2 and 3. The observations of Mr E. E. Howell and of the late Mr. A. R. Marvine, published in vol. iii, of Lieut. Wheeler's Reports, and in part unpublished. 4. The observations of Dr. J. S. Newberry, published in Ives' "Explorations of the Colorado," and in part unpublished. 5. The writings of Mr. Clarence King, "Fortieth Parallel Survey," vol. iii. 6. Mr. T. B. Comstock's report in the U. S. Engineers' "Reconnaissance of northwestern Wyoming." 7. Prof. E. D. Cope's report to Lieut. Wheeler, published in the U. S. Engineer report for 1875.

It is evident that if two monoclinal folds are combined back to back, the result will be an anticlinal; if they are joined foot to foot, they will form a synclinal. Hence the monoclinal fold is a simpler element of displacement than either of the others.

When a portion of the earth's crust—it may be one that is measured by miles, or one that is measured only by feet—is moved bodily either up or down, while the portion adjacent to it is not so moved, the line along which they adjoin, will be marked by a fault, by a monoclinal fold, or by some combination of the two. The fault and the monoclinal fold are alternative manifestations of simple displacement, and are, in a certain sense, equivalent. There are several different ways in which they are combined with each other. If one travels along the line of displacement that separates two blocks of strata which stand at different levels; he may find that at one point the beds are continuous, and curve downward from the upper level to the lower; and that at another point they are broken across, and the dissevered edges have slidden past each other. Or, if one could descend into the earth along the plane of dislocation, he might find that one stratum had been fractured, while another, less rigid, or coerced perhaps by a greater pressure of superincumbent rock, had been only flexed. A third mode of combination is exhibited when a bed yields at first by flexure, and is finally fractured before the completion of the dislocation. These phenomena are illustrated by figure 2, which is an ideal representation of two blocks of strata, *A* and *B*, cut out from their surroundings, so as to exhibit the manner of their relative displacement. The front of the segment shows a flexed bed underlying a faulted one. The top of the segment shows a fault at the front, a monoclinal fold at the back, and a compound displacement midway.

2.



The monoclinal fold is not unknown in other parts of the world, but it has attracted little attention, and I am not aware that it has been described as abundant in any region. But in the region of the Plateaus it is not merely a feature of occasional occurence; it is a characteristic type of displacement, and is rivalled in frequency only by the fault.

Let us now turn from the displacements, to the disturbed masses of rock which they divide. A fault or a monoclinal fold is merely the record, at the margin of a solid block, of a movement that has affected the entire block, and it bears the same subsidiary relation to the movement of the block, that a

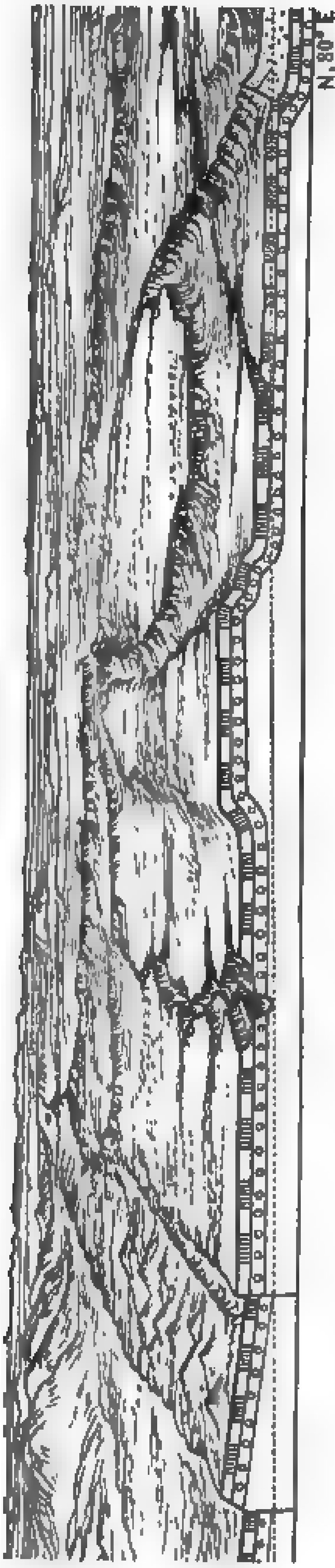


Fig. 3. Section from west to east across the plateaus north of the Grand Cañon of the Colorado, with bird's-eye view above. Horizontal scale, 16 miles to the inch; vertical scale, 4 miles to the inch. The base line marks the level of the ocean; the dotted line above it, the level of the river.

line bears to the angle or area which it limits and defines. A large portion of the Plateau region is divided into great blocks —usually a few miles in width and many miles in length—and these have been unequally lifted above the ocean which deposited their common sediments, so that each differs from its neighbor in altitude. They are bounded by lines of displacement. The blocks which have been lifted highest have been most exposed to erosive agencies, the tendency of which is to pare away eminences and reduce all to a common level: but as a rule, the highest plateaus mark the positions of blocks that have risen above their neighbors. The forms of many blocks are perfectly portrayed in the topography, and all can readily be traced out and defined by the study of the displacements.

In illustration I have borrowed, through the kindness of Major Powell, a wood-cut from his report of the "Exploration of the Colorado," and if the reader will examine it attentively, he will obtain a clearer idea of the structure I have described, than I can hope to convey in words. The sketch is not an ideal one, but was carefully drawn to represent a tract of country, lying in Utah and Arizona, of which the main geological features are clearly understood. The geological section in the foreground is, in the main, the section which is exposed in the walls of the Grand Cañon, and is 106 miles long. The vertical scale is four times as great as the horizontal. The base line marks the level of the ocean, and the dotted line the level of the Colorado river. The rock bed marked with small circles stands for the Lower Aubrey Group, a member of the Carboniferous System; the one above it for the Upper Aubrey Group, also Carboniferous, and the dotted stratum, seen at the right, is the so-called Trias. In the bird's-eye view beyond the section, the foreground is of plateaus floored by the limestone of the Upper Aubrey, and beyond rise terraces built of Triassic and more recent strata. Five displacements are exhibited. Beginning at the left: the Hurricane displacement is a fault where it is intersected by the section, and has a throw of 2,500 feet. Seventy miles farther north it is a combination of fault and fold. The throw of the To-ro′-weap fault is only 800 feet, and it disappears altogether in a few miles. The West Kai′-bab displacement is a monoclinal fold as far as it appears in the sketch, but farther south it changes to a fault. Its throw is 2,000 feet. The East Kaibab displacement is a double monoclinal fold in the foreground but a single one in the distance. Its total throw is 3000 feet. The throw of the Paria displacement is 1800 feet. It is known only as a simple fold. Along the lines of the first three displacements the eastern wall has risen, or the western has fallen; but with the remaining two the reverse is the case.

[To be continued.]

ART. III.—*Notices of Recent American Earthquakes*—No. 6; by Prof. C. G. ROCKWOOD, Jr., Rutgers College.

IN the following notices, facts given by *single* newspaper reports, and which could not be otherwise verified are printed in smaller type, and the source from which they were obtained is indicated.

For information received I am indebted to John M. Batchelder, of Boston, and Samuel Barnet, of Washington, Ga.

1874.

May.—The disturbances at Bald Mountain, N. C., in February and March, already noticed (III, ix, p. 332) were reported as continuing at intervals during the months of April and May. (U. S. Signal Service.)

July 23.—A light shock at Camp Russell, Neb. (U. S. Sign. Serv.)

Aug. 3.—During the evening a light shock from the east at Clifton, San Bernardino Co., Cal. (U. S. Sign. Serv.)

Dec. 12.—A slight shock between 10 and 11 P. M at Garrison's, N. Y.

1875.

January.—Earthquakes preceded and accompanied an eruption of the volcano Trölladyngja, in the central part of Iceland. The volcanic disturbance appears to have begun by subterranean thunders during December, 1874, extending through nearly two-thirds of the island. Early in January, 1875, earthquakes occurred in all directions and then an old extinct volcano near Vatrayskud opened and for four weeks continued to emit ashes, lava, etc. When this eruption ceased, another extinct volcano near Myvatu, 100 miles farther north, opened and continued in action for several weeks. Both of these eruptions occasioned great destruction of life and property. Early in March there seemed to be a general upheaval of the earth in the whole central portion of the island. The ashes from these or still later eruptions fell to the depth of several inches on the coast of Norway in the latter part of April. It is stated that "the geysers have dried up since the eruption began, and instead of water emitted quantities of hot smoke and ashes."

Jan. 24.—A heavy shock at 4 A. M. in Butte, Plumas, and Sierra counties, Cal.; felt also at Sacramento, Cal., and Carson City, Nev., where two shocks were reported, the first light, the second quite severe and lasting several seconds. The direction was from the northeast.

Feb. 7.—Two severe shocks at San Francisco, Cal., the first at 10.56 and the second at 11.50 A. M., each lasting two to four seconds. (U. S. Sign. Serv.)

Feb. 16.—A shock at Orezava and Minatitlan on the Isthmus of Tehuantepec. (J. M. B.)

Feb. 11 and 18.—A letter from Guadalajara, Mex., dated March 2, 1875, says: "Since the 11th ult. we have had almost continually slight shocks of earthquake. In all we have had but four very severe shocks; the first (two?) on the night of the 11th and two on the 18th. The majority of the churches in Guadalajara are greatly damaged. In San Cristobal, a small village about eight leagues from this city, 35 or 40 lives have been lost and nearly all the houses reduced to ruins."

March 9 and 10.—The same writer says under date of March 10: "The earthquakes continue. We had one yesterday that lasted three minutes, not severe. We felt a sharper one to-day at 1.20 P. M. but it only lasted a few seconds."

March 9.—A shock at Phœnix, R. I. (J. M. B.)

April 1.—A heavy shock in the evening at Eureka, Nev. (J. M. B.)

May 6.—A shock at Wolfborough, N. H. (J. M. B.)

May 15.—A slight shock about 10.15 A. M. at Cambridge, West Roxbury and Milton, Mass.

May 18.—A very destructive earthquake occurred at 10.10 A. M. in the Colombian Andes. The area affected extends from Carthagena and Maracaybo on the north to Bogota and Honada on the south, over six degrees of latitude. The center of disturbance was at the city of San José de Cucuta. This is a city of Venezuela, situated on the border of New Grenada, in N. lat. 7° 30′, W. long. 72° 10′, and before the catastrophe had a population of 18,000. It is between the two ranges of the Andes which unite not very far south of the city. The first premonition of the disturbance at Cucuta was a subterranean rumbling noise heard on the night of the 17th, but unattended by any tremors. At 11.10, (some accounts 11.30) on the forenoon of the 18th two tremendous shocks of earthquake occurred followed after a short interval by three others of nearly equal intensity. By these shocks, the city and most of the surrounding villages within a radius of twenty miles were completely destroyed, with great loss of life and property. In Cucuta only one building remained standing; and in San Cristobal (population 11,000) only one house was left and that so shattered as to be unsafe.

The destruction involved nine villages in Venezuela, chiefly in the department of Merida, and ten in New Grenada in the departments of Santandar and Pamplona. The loss of life is estimated at 5000, and of property at $7,000,000. Immediately after the first shocks, the Lobotera volcano, near the city, began to emit masses of molton lava, which falling in the city set fire to the ruins, and thereby added to the destruction, the

horrors of which were still further enhanced by the pillage and robbery which took place. Lighter shakings were felt in various parts of this region for a number of days after the first shock. Thus advices from Maracaybo, May 29, say: "Light shakes here every day since." In Cucuta, Trujillo, Merida, and Mendoza, "tremors perceptible at intervals for forty-eight hours." A telegram from Bucaramanga, May 24, says: "The earthquake continued last night. The cathedral in Pamplona fell." A telegram from Chiquinquira, May 22, says: "the shocks are repeating. Two last night, one to-day." It was noticed as a remarkable fact that the disturbance was only felt on the west side of the mountain range.

May 18.—A prolonged shock just before midnight at St. Thomas, W. I. (J. M. B.)

May 30.—Advices of this date from City of Mexico say: "slight shocks have been felt in Jalisco." (N. Y. Times.)

June 4.—A shock at 3 A. M. felt on board the ship Hamilton in N. lat. 19° 16′, W. long. 57° 51′. "When the disturbance first began the sea was quite smooth, but as the shock increased in violence the waters became correspondingly agitated. Suddenly the vessel received a shock as if she had grounded, and a peculiar rumbling noise filled the air. Simultaneously with the shaking the sky assumed a dull leaden hue. The atmosphere was also thick and hazy. There was little if any wind at the time, yet the vessel was tossed about as though in the midst of a gale. The duration was long enough to enable those who were below to reach the deck, estimated as fully ten minutes."

June 13.—Several shocks at Chinaltenango, San Salvador.

June 16.—A shock at San Francisco, Cal. (J. M. B.)

June 18.—A shock in the forenoon in western Ohio and Indiana. It was most severe in the vicinity of Urbana and Sidney, Ohio, where walls were cracked, chimneys thrown down, etc.; but it was sensibly felt at Columbus, O., and Indianapolis, Vincennes and Jeffersonville, Ind., and slightly at Cincinnati and Chicago. It was not felt at Terre Haute, nor in the vicinity of Lafayette and Logansport, Ind. The statements in regard to time are various and contradictory. The United States Signal Service Observer at Indianapolis reports the shock as occurring at 7.43 A. M. All other accounts vary from 9 to 11 A. M. *No account mentions more than one shock.*

Slight shocks were felt in San Francisco on the same forenoon.

July 3.—Three shocks at 12.05 P. M. at Nuevitas, Cuba. The first and last slight, the second rather severe, the whole lasting about fourteen seconds. (N. Y. Times.)

July 28.—A shock at 4.10 A. M. felt quite generally through-

out the northwestern part of Connecticut. It extended from Hartford and Springfield on the east to the line of the Housatonic R. R. on the west, and from Danbury and Waterbury on the south, to Chester and Becket, Mass., on the north, being felt at numerous places in Litchfield and Hartford counties. At most places the shock was preceded or accompanied by a rumbling noise. At Collinsville it lasted fifteen seconds. At Winsted it is stated to have lasted forty seconds, the sound coming from the north and passing away toward the south.

July 28.—A shock at 6.05 P. M., at Milledgeville, Ga., with a loud explosion. (Atlanta Herald.)

July 31.—Advices of this date from the City of Mexico, report an earthquake in Jalisco. (N. Y. Times).

Aug. 3.—A shock at 3 A. M. in St. Thomas, W. I.

Aug. 8.—A heavy shock in the morning at Hollister, Cal. (J. M. B.)

Aug. 29.—A shock was felt at 8.30 P. M., on board the bark St. Lawrence, in N. lat. 18° 50′, W. long. 61° 30′, being between St. Thomas and the Island of St. Bartholomew, 140 miles from land. It lasted thirty seconds. (N. Y. Herald.)

Sept. 17.—Three shocks at St. Vincents, W. I. The last about 9 P. M. was rather severe. (London Times Correspondence.)

Sept. 25.—A shock about 9 P. M. at Stepney, Conn. (New Haven Palladium.)

Oct. 7.—Slight shocks at Memphis, Tenn., and Cairo, Ill. (U. S. Sign. Serv.)

Oct. 14.—A sharp shock about 6 P. M. at San Francisco, and in the Santa Clara Valley, Cal. The vibrations were from east to west. Reports from various points on the coast from Santa Cruz to Cape Mendocino, mention a heavy sea without wind, and the waves rolling up on the beach 100 to 300 feet beyond the usual high water mark, for several days after the above. From this it might be inferred that this earthquake had its origin somewhere in the Pacific Ocean.

Oct. 15.—A shock at 1 A. M. at Kingston, Jamaica, W. I. (J. M. B.)

Oct. 27.—Three shocks in the night at Memphis, Tenn.; strong enough to rattle windows. Also a shock, probably the same, at 9 P. M. at Purdy, McNairy Co., Tenn.

Oct. 31.—A slight shock at 9.18 P. M. at Cambridge, Mass., of three or four seconds duration. Barometer 29·70 in.

Nov. 1.—A somewhat severe earthquake was felt at 9.55 P. M., in the northern part of Georgia. It was felt at Gainesville, Atlanta, Madison, Athens, Union Point, Washington, Augusta, Forsyth and Macon, Ga., and at Spartanburg and Columbia, S. C. It lasted about thirty seconds, and at Wash-

ington and Augusta some observers noticed two or three shocks. A rumbling was heard at the former place. The reports of the direction of vibration are too contradictory to be briefly stated. No damage was done, but the shock was sufficiently strong "to cause a mirror to nod back and forth from the wall."

Nov. 2.—Advices of this date from San Francisco say: "A severe shock of earthquake is reported at Fort Yuma on the Colorado River."

Nov. 7.—A heavy shock in San Benito County, Cal., accompanied by a harsh rumbling noise. The direction of vibration was from east to west.

Nov. 8.—A shock at 4.40 A. M., felt at Leavenworth, Lawrence, Burlingame (direction S.W. to N.E.), and Manhattan, Kansas. At the latter place the time was "about 5 A. M.," the direction west to east and lasting a minute.

Nov. 12.—A shock at 2 A. M. at Knoxville, Tenn., lasting ten seconds. The vibration was from west to east, and accompanied by a rumbling noise.

Nov. 14.—A shock at San Francisco and San Jose, Cal. (U. S. Sign. Serv.)

Nov. 15.—A smart shock at 7.55 P. M. at San Francisco, Cal.; vibrations east and west.

Nov. 27.—A shock at San Francisco, Cal. (U. S. Sign. Serv.)

Dec. 1.—Two slight shocks at 4 and 6 A. M. at Keene, N. H.

Dec. 3.—A heavy shock in the afternoon at Grass Valley, Cal., lasting ten seconds, vibrations north and south. Felt slightly at 3 P. M. at Carson City, Nev.

Dec. 4.—The town of Abancay, Peru, was destroyed by an earthquake, "between 4 P. M. of the 4th and 9 A. M. of the 5th, no less than thirty-seven shocks occurred, some of them very severe" This town is east of the Andes and some fifty miles from Cuzco.

Dec. 8.—On the night of the 8th and 9th, an earthquake occurred in Porto Rico by which the town of Arecibo was almost entirely destroyed, "two churches and only six houses remaining."

Dec. 8.—On the same day as the preceding, hour not stated but apparently about breakfast time, the bark Mora experienced an earthquake at sea in N. lat. 10° 7′, W. long. 42°.

Dec. 9.—A slight shock at 3 A. M. at Nebraska City, Neb.

Dec. 15.—A shock at 2.45 P. M. at Maricopa Wells, Arizona Terr. (U. S. Sign. Serv.)

Dec. 21.—A shock at Santa Barbara, Cal. (U. S. Sign. Serv.)

Dec. 22.—An earthquake was felt about 11.45 P. M. in Virginia. It was most severe at Richmond and vicinity, where three distinct shocks were noticed, lasting twenty or thirty

seconds, and accompanied by a rumbling noise. The shocks "were not sharp or sudden, but coming on rather slowly, swelling in force, and then quickly dying out." The direction of the vibration was north and south, and it was sufficiently strong to knock down plastering, etc. It was felt toward the north as far as Washington and Baltimore, and toward the northwest at Staunton and Gordonsville, at which latter place the time is stated at 11.30, and the duration "fully three seconds." The U. S. Signal Service reports: "Two shocks at 11.30 at Fortress Monroe, Va.; about 11.30 at New Market, Ind.; shock lasting twenty seconds at 11.45 at Greensboro, N. C.; two shocks from east-southeast to north-northwest, the first lasting five or six seconds, the second not quite so heavy at 11.40 (Washington time) at Alto Vista, Va.; two shocks from east to west, first lasting ten or fifteen seconds, the second milder, at 11.33 at Petersburg, Va.; shock from northeast to southwest with rushing roaring noise at Weldon, N. C."

Dec. 23.—A shock at night in Placer, Nevada and Yuba Counties, Cal.

Dec. 24.—A shock in the evening at Grass Valley, Cal. (N. Y. Times.)

1876.

Jan. 7.—Three shocks at the Island of St. Thomas, W. I, in the morning, "the first at about four o'clock, the second at about half past four, which was very severe, and the last three minutes later." (Newark Daily Advertiser.)

Jan. 7.—A shock at 2.20 P. M. at Warner and Contoocookville, N. H. Its apparent course was from west to east and its duration two minutes.

Jan. 8.—A shock at 4.30 P. M. at Lockport, N. Y. (U. S. Sign. Serv.)

Jan. 15.—A severe shock at midnight at China, Me.

Jan. 21.—A shock between 3 and 4 A. M. at San José, Santa Cruz and San Francisco, Cal. (U. S. Sign. Serv.)

Jan. 27.—Two shocks at Adrian, Mich. (U. S. Sign. Serv.)

Jan. 29.—A shock at 9.05 P. M. at Annapolis, Md. (U. S. Sign. Serv.)

Feb. 7.—A shock in the City of Mexico. (U. S. Sign. Serv.)

Feb. 27.—A shock at Detroit, Mich.

March 25.—Two slight shocks at 6 A. M. and 1 P. M. at Oakland, Cal. (U. S. Sign. Serv.)

April 10.—A shock was felt in a large portion of St. Mary's County, Md., attended by a rumbling sound. (N. Y. Times.)

New Brunswick, N. J., May 3, 1876.

ART. IV.—*On Roscoelite, a Vanadium Mica;* by JAMES BLAKE, M.D., San Francisco, California.

THE mineral, to which I have given the name of Roscoelite, —in honor of Professor Roscoe, of Manchester, who has done so much for the chemical history of vanadium,—is a well marked species of mica, containing quite a large percentage of vanadium. It was found in a gold mine at Granite Creek, El Dorado County, in the lower hills on the western slope of the Sierra Nevada. It occurs in the hanging wall of a small quartz vein, the country rock being porphyry. The mica appears to have been principally deposited in fissures in the porphyry, and is usually found in layers from a tenth to half an inch thick, and seldom extending continuously for more than two or three inches. It is also found filling cavities in the quartz. The crystals are quite brilliant, of a dark-green color, seldom more than 0·1 inch long, and, when occurring in fissures, form two series starting from each side of the fissure and meeting in the center. They are also found in nodules with a stellar arrangement, more particularly in the cavities of the quartz. They are strongly doubly refracting. Sp. gr. 2·33. They weather into a light yellow wacke. The whole thickness of the vein-matter in which the mica is found is not more than a few inches. The mine in which it occurs has been worked for gold, and it is in these micaceous deposits that the greater part of the gold is found. Some portions are extremely rich, as much as $240 having been washed out from a single panfull; and while at the mine I saw $40 taken from a few handsfull. The gold is commonly found in the form of fine scales which have been deposited between the crystals of the mica. So generally is it diffused that it is impossible to find a piece of the mica as large as a bean that does not contain gold. The mine is worked by means of an open cut, now about 30 feet deep and 150 feet long.

The most interesting fact connected with this mineral is the large proportion of vanadium it contains, and that too, in a form in which it has not before been found, unless the small traces of it detected in some basalts should be part of an analogous compound. When I first discovered the mineral, I expected to find a mica rich in chromium, and, on heating some of it in a test tube with HCl, I obtained a green solution. Finding that by continued boiling with acid the whole of the color was entirely removed from the mica, I availed myself of this method to determine the quantity of what I considered to be chromium; fusing the residue from the acid solution with carbonate of soda and niter, and precipitating with lead, I also ascertained the amount of the alkalies; and, in presenting some specimens

of the substance to the Microscopical Society and at the Academy of Sciences of California in September, I made the general statement that it was a potash-mica, containing 23 per cent chromic oxide and traces of lithia. It was not until I had sent a specimen of the mineral to Dr. Genth to analyze that the presence in it of vanadium was discovered, and to him is due the entire credit of having first detected the true character of this interesting mineral. I have availed myself of the action of nitrohydrochloric acid on the mineral to prepare a considerable quantity of vanadic compounds for physiological experiment, as this affords about the easiest method of obtaining vanadic acid, although it is impossible thus to extract all the vanadium from the mica.

Art. V.—*On some American Vanadium Minerals;* by F. A. Genth.

1. *Roscoelite.*

I am indebted to Dr. James Blake of San Francisco, California, for a small quantity of the very interesting mineral, which he called "Roscoelite," in honor of Professor Roscoe, whose important investigations have put vanadium in its proper place among the elements.

Roscoelite occurs in small seams, varying in thickness from $\frac{1}{50}$ to $\frac{1}{16}$ of an inch in a decomposed yellowish, brownish or greenish rock. These seams are made up of small micaceous scales, sometimes $\frac{1}{4}$ of an inch in length, mostly smaller and frequently arranged in stellate or fan-shaped groups. They show an eminent basal cleavage. Soft. The specific gravity of the purest scales (showing less than one per cent of impurities) was found to be 2·938; another specimen of less purity gave 2·921. Luster pearly, inclining to submetallic. Color dark clove-brown to greenish-brown, sometimes dark brownish-green.

Before the blowpipe it fuses easily to a black glass, coloring the flame slightly pink. With salt of phosphorus gives a skeleton of silicic acid, a dark yellow bead in the oxidizing flame, and an emerald-green bead in the reducing flame. Only slightly acted upon by acids, even by boiling concentrated sulphuric acid; but readily decomposed by dilute sulphuric acid, when heated in a sealed tube at a temperature of about 180° C., leaving the silicic acid in the form of white pearly scales, and yielding a deep bluish-green solution. With sodic carbonate it fuses to a white mass. The roscoelite, which I received for investigation was so much mixed with other sub-

stances, such as gold, quartz, a feldspathic mineral, a dark mineral and very minute quantities of one of orange color, that it was impossible to select for analysis material of perfect purity. For this reason I have delayed the publication of my results, which were obtained over one year ago, in the hope of being able to repeat my analyses with better and purer specimens; but I now give the results of my analyses because there is no prospect of getting any more of this mineral, as will be seen from a letter of Dr. Blake, dated San Francisco, April 5th, 1876, in which he says, that the mine in which it occurs cannot be worked any farther until a tunnel has been run, and that it is quite uncertain when this will be done.

Although by no means perfect, my results approach the truth and give a fair idea of the composition of the mineral, even if the evident admixture of other minerals, varying in the different samples analyzed, from about one to perhaps over twelve per cent, does not permit one to calculate the atomic ratio of the constituents and establish the constitution of this species. There is especially an uncertainty with reference to the quantities of silicic acid, alumina and potassa which belong to the roscoelite, or which may have been introduced by admixtures of feldspathic and other minerals, as will appear from the results given below, which show that the mineral, when decomposed with sulphuric or dilute hydrofluoric acid generally gives only about six per cent of potassa, while fusion with calcic carbonate and ammonic chloride yields from eight to nine per cent. Some of these uncertainties could have been removed, if a larger quantity of the mineral had been at my disposal.

Particular attention was paid to the correct determination of the vanadium and the form in which it exists in the roscoelite.

The separation of vanadium is attended with great difficulties, and I have not found any of the methods of separation to give fully reliable results. This is in part owing to the incomplete precipitation of the vanadic acid, and in part to the impossibility of washing the precipitates completely without loss of vanadium. It was therefore always determined by the only method which I found to give fully reliable results—by titration with potassic permanganate.

After the separation from the other elements, the vanadic acid was reduced by hydrosulphuric acid into V_2O_4, which, after the excess of hydrosulphuric acid had been expelled by continued boiling, was re-oxydized into V_2O_5 by the permanganate. I have satisfied myself by numerous experiments that, no matter whether only a very minute quantity of sulphuric acid is present, or a very large excess, the V_2O_4 is completely oxidized into V_2O_5 by this process.

For the determination of the state of oxydation of the vana-

dium in the roscoelite, a quantity of the mineral was dissolved in dilute sulphuric acid in a sealed tube at a temperature of about 180° C., and was titered after cooling; the liquid was then reduced by hydrosulphuric acid, and after boiling off the excess of the latter, it was again titered. From the quantity of oxygen required for oxidation in both cases it was found that vanadium in the mineral is present as $V_6O_{11} = 2\,V_2O_3, V_2O_5$.

The determinations of the other elements were made by the usual methods.

The finely-powdered mineral was dried (unless otherwise stated) for two days over sulphuric acid, and the different samples gave the following results:

(*a.*) *Purest scales.*—The analysis was made by dissolving one portion in sulphuric acid and determining in this the quantity and state of oxidation of the vanadium, the silicic acid and insoluble impurities. The latter were left behind in dissolving the silicic acid in sodic carbonate and gave 0·85 per cent; a second portion was decomposed by sodic carbonate and nitrate, and a third for the determination of the alkalies by J. L. Smith's method. The V_6O_{11} given below is the mean of the two determinations. (*b.*) Another sample, not quite as pure as *a*, was analyzed by fusion. (*c.*) Still more contaminated with impurities, was analyzed by dissolving in dilute sulphuric acid in a sealed tube, &c., *cα* is the result of this analysis, *cβ* after deducting 11·45 per cent of impurities. (*d.*) Another sample was decomposed by dilute hydrofluoric acid; the analysis was unfortunately lost excepting the determinations given below; the material for this analysis had not been dried over sulphuric acid. (*e.*) This sample was dried over sulphuric acid for several weeks; a portion, which was decomposed by sulphuric acid, gave 5·37 per cent insoluble silicates, 0·23 per cent of gold and 43·24 per cent of silicic acid; the V_6O_{11} was determined by difference. The results given below were obtained by decomposing the mineral by fusion.

		a	*b*	*cα*	*cβ*	*d*	*e*
Insoluble silicates, quartz, gold, &c.	=	[0·85]	....	11·45	....	8·91	[5·60]
SiO_2	=	47·69	47·82	43·46	48·60	....	46·81
Al_2O_3	=	14·10	12·60	10·52	11·76	....	15·78
FeO	=	1·67	3·30	2·03	2·27	....	1·58
MgO	=	2·00	2·43	1·74	1·95	....	2·31
CaO	=	trace	trace	0·20	0·23	....	trace
Na_2O (trace Li_2O)	=	0·19	0·33	0.30	0·34	5·96	0·60
K_2O	=	7·59	8·03	5·35	5·98		8·89
V_6O_{11}	=	22·02	21·36	20·50	22·92	....	20·16
Ignition	=	4·96	5·13	5·32	5·95	6·34	3·87
		100·22	101·00	100·87	100·00		100·00

A mineral, very similar in composition and perhaps a compact impure variety of roscoelite is found associated with the scales. It has the appearance of a massive dark green chlorite or that of some varieties of serpentine. The analysis was made by fusion, &c., and gave:

SiO_2	= 46·09	Na_2O	= 0·18
Al_2O_3	= 17·46	K_2O	= 8·66
FeO	= 1·95	V_6O_{11}	= 17·53
MgO	= 2·18	Ignition	= 6·37
			100·42

2. *Psittacinite, a new hydrous vanadate of lead and copper.*

In a paper on American Tellurium and Bismuth minerals, read before the American Philosophical Society at the meeting of August 21st, 1874 (Proc. Am. Phil. Soc., xiv, 223–231), I mention, on the authority of Mr. P. Knabe, a siskin-green pulverulent mineral from the "Iron Rod Mine," Silver Star District, Montana, as a *new* "Tellurate of lead and copper." I had at that time no opportunity to examine into the merits of this mineral, having mislaid the small sample which he had sent me. On receiving a copy of my paper, Mr. Knabe furnished me with several specimens, which gave me a sufficient quantity of fair material for an analysis. A qualitative examination proved it to be a hydrous *vanadate* of lead and copper and *not a tellurate.*

When I communicated this result to Mr. Knabe he gave me an interesting account of how he fell into his error. At the Uncle Sam's Lode, in Highland District, occurs with the tetradymite a siskin-green mineral, which has not yet been analyzed, but which appears to be a tellurate. It looks exactly like the pulverulent variety of the psittacinite from the Iron Rod Mine. When Mr. K. dissolved the latter in hydrochloric acid, the evolution of chlorine indicated the presence of a higher oxide; the solution precipitated with an excess of ammonic sulphide gave sulphides of lead and copper and a filtrate which, on addition of an acid, gave a black precipitate—vanadic sulphide—which he mistook for tellurous sulphide.

Psittacinite occurs in very thin cryptocrystalline coatings, sometimes showing a small mammillary or botryoidal structure, also pulverulent; color siskin-green, sometimes with a grayish tint, to olive-green. Before the blowpipe it fuses easily to a black shining mass. With fluxes gives the reactions of vanadium, lead and copper. Soluble in dilute nitric acid, the solution yielding on evaporation a deep red mass.

As it was impossible to get any of the mineral in a pure state, I had to use coatings with quartz attached to them, sometimes contaminated with a little limonite; but these admixtures

could not influence the analysis farther than very slightly with reference to the amount of water which it contains.

The following are my results:

		a	*b*	*c*	*d*	*e*
PbO	=	41·36	50·17	42·89	27·12	42·38
CuO	=	14·34	16·66	14·72	9·75	15·03
V_2O_5	=	14·64	19·05	15·87	9·96	15·77
H_2O	=	7·42	not determined		....	7·25
SiO_2	=	15·13	7·60	10·10	48·84	15·57
Al_2O_3	=	1·29		3·83		4·00
Fe_2O_3	=	2·72		2·19		
MgO	not det.			0·65		
CaO				0·15		

The oxygen ratio of PbO : CuO : V_2O_5 : H_2O in the above analyses is in:

a =	2·97	:	2·89	:	6·41	:	6·59
b =	3·60	:	3·36	:	8·34	:	....
c =	3·08	:	2·97	:	6·95	:	....
d =	1·94	:	1·96	:	4·36	:	....
e =	3·04	:	3·03	:	6·90	:	6·44
or *a* =	1	:	0·97	:	2·16	:	2·19
b =	1	:	0·93	:	2·31	:	....
c =	1	:	0·97	:	2·26	:	....
d =	1	:	1·01	:	2·25	:	....
e =	1	:	1	:	2·27	:	2·12

The average of the five analyses gives the ratio of

1	:	0·98	:	2·25	:	2·15
9	:	9	:	20	:	18

corresponding to—

$$3\,(3\,PbO, V_2O_5) + (3\,CuO, V_2O_5) + 6\,(CuO, H_2O) + 12\,H_2O.$$

giving the following percentage:

PbO	=	53·15
CuO	=	18·95
V_2O_5	=	19·32
H_2O	=	8·58
		100·00

Psittacinite occurs, sometimes associated with gold, and small quantities of cerussite, chalcopyrite and limonite upon quartz, at several of the mines in Silver Star District, Montana, especially in the Iron Rod Mine and New Career Mine, and its occurrence in these mines is looked upon as a favorable indication, for, when it is met with, the vein becomes immediately or soon after rich in gold. This mineral has been called "psittacinite" from psittacinus, siskin- or rather parrot-green.

University of Pennsylvania, Philadelphia, May 16th, 1867.

ART. VI.—*On a Disease of Olive and Orange Trees, occurring in California in the Spring and Summer of* 1875; by W. G. FARLOW, Assistant Professor of Botany in Harvard University.* With Plate III.

DURING the past summer, numerous complaints have come from southern California of a fungus which had attacked the olive and orange trees, and which was causing a considerable loss of those two crops. Our attention was first called to the subject by Dr. H. W. Harkness, who, in a letter from San Francisco dated May 11, sent a specimen of the fungus on an orange-leaf from southern California. Of the extent of the ravages of the fungus at that date no information has been received; but, as in a letter from San Diego, dated June 3, Mr. D. Cleveland† wrote that there was no trace of the fungus in that vicinity, we may suppose that the disease first appeared not far from Santa Barbara, where we have definite knowledge of its occurrence, and where great damage was done later in the summer. In a letter from Dr. George Thurber dated September 20, enclosing some specimens of the fungus, is the following from a correspondent in Santa Barbara: "We are troubled with our olive, lemon and orange trees. A small fungus appears on the leaves, twigs, and branches, at first visible only with a microscope, and of a green color. As it increases in size it turns brown, and then black. The olive is so exhausted that it is unable to fruit. The orange and lemon stand it better, but their fruit is so inferior as to be practically worthless." On the day of the receipt of Dr. Thurber's letter, another was received from Professor Dana, also enclosing specimens from Santa Barbara.

From the general tenor of letters from California, it is evident that, if this is not the first year of the appearance of the disease, it is, at least, the first in which it has attracted general attention; that its effect on the olive and orange crops has not been slightly, but markedly injurious; and that, in its advanced stages, there is present on the leaves and stems a blackish substance, which is universally regarded, by those who have formed any opinion on the subject, as a fungus. We have received, at different times, from California specimens of leaves and stems of orange and olive trees covered with the black growth, and have been able to study the fungus, which presents some points not without interest in a botanical point of view; and, if our conclusions do not point to a direct remedy, it will be conceded, we hope, that we have contributed toward removing some mis-

* Copied from the Bulletin of the Bussy Institution.

† We are in receipt of a letter from Mr. Cleveland, dated early in January, 1876, in which he sends specimens of the fungus on orange-leaves, which, he writes, is at that time common at San Diego.

conceptions as to the nature of the disease. At this distance, remote from all opportunities of observing the disease on living trees, there are, of course, some points in the development of the fungus which we have not been able to study; and our correspondence has not been sufficiently extensive or minute to enable us to give any statistics of the ravages of the disease, to ascertain the climatic or other changes which have preceded or accompanied the breaking out of the epidemic, or to decide whether it is the same form of disease which has been reported to occur in Florida. Our specimens present the disease as it appears when in a somewhat advanced stage, and after the leaves and stems have become so changed as to attract attention.

Mycelium.—The leaves of the olives which are affected by the disease are somewhat curled and shrivelled, and are of a browner color than normal leaves which have been gathered but a few weeks. On both surfaces of specimens sent us are black spots of greater or less extent, but in no case is the leaf perfectly black. On the upper surface the black spots are more numerous, more distinct in outline, and harder in substance, than on the lower, where they were more diffuse and of a powdery consistence. The twigs, of which we received only small specimens, are covered with spots which resemble more closely those on the upper than on the lower surface of the leaves. In one specimen the spots are nearly confluent, and the bark is visible in only a few places. After the leaves or stems have been soaked in water for a short time, the black substance can be scraped off without the least trouble, leaving the bark tolerably clean. The black substance, when seen with a magnifying power of four hundred diameters, is found to be composed of the stellate hairs peculiar to the olive, over which is growing a fungus, to the dark color of whose mycelium the spots owe their color. The mycelium is very variable in appearance. As a rule, it is composed of moniliform hyphæ, whose cells are ·006 mm. by ·008 mm., and in some places almost spherical. The color of the cell-wall is a dark or purplish brown, and in most of the cells there is a comparatively large-sized oil globule. These hyphæ branch in all directions, and the cells of the branches grow constantly longer, narrower, and paler, although, in all cases, retaining a tinge of brown. The relation of the mycelium to the stellate hairs and outer part of the twigs and leaves is clearly seen in cross sections. The hyphæ run along the surface of the epidermis and of the hairs, which it will be remembered resemble a broadly-opened, short-handled parasol. They are twined closely round the stems of the hairs, so closely, that the fungus cannot be removed without tearing them off. They do not enter into the cells of the olive, and there are no haustoria as in the case of some of the leaf parasites belonging

to the *Erysiphei.* Occasionally there are little knob-like projections of the cells which seem to indicate haustoria; but, by the most careful examination which we have been able to make, we have not been able to see that they enter into the cells of the stellate hairs or epidermis and act like haustoria. The surface of the hairs and epidermis, however, seems covered with a sticky substance (of which we shall have more to say hereafter), to which the hyphæ closely adhere. Plate 3, Fig. 2, shows one of the stellate hairs seen from below, with a portion of the mycelium growing upon it.

Various modifications of the mycelium are found principally on that portion growing on the outer part of the stellate hairs exposed to the air. After reaching a certain stage of development, they grow together in such a way that the hyphæ coming together laterally form a sort of membrane, as shown in Plate 3, Fig. 1, *d.* This membrane is composed of only one thickness of cells, but is very uneven as it follows and conforms to the inequalities of the hairs. Its general direction is parallel to the surface of the leaf or stem on which it is found.

Conidia.—The hyphæ, at their free ends, branch in all directions, and bear reproductive bodies of several kinds. The simplest form is that shown in Plate 3, Fig. 3, *d*, where the ordinary cells of the mycelium divide by cross partitions into two parts, which do not respectively grow to the same shape as the mother cell, but remain together two by two, as shown in the figure; the hypha becoming zigzag by the alternate lateral displacement of the pairs of cells, which finally drop off and readily germinate, each cell producing a germinal tube. In other parts of the mycelium, the terminal cell of certain threads divides by means of partitions, parallel to and at right angles to the axis of the filament, until a compound body is formed, which resembles the spores of the so-called genus Macrosporium. These bodies, which can only be described as irregular conglomerations of cells of an oval outline, are produced in great abundance and average ·015 mm. by ·025 mm., but are often much larger, though often smaller. They easily drop from their attachments and germinate, each cell being capable of producing a germinal tube. Other hyphæ, rising at right angles to the plane of the membranous portion of the mycelium, grow more and more attenuated, and branch at the tip; the terminal cells divide in two, as in Plate 3, Fig. 3, *c*, fall from their attachment, and germinate. This last modification of the hyphæ, which is by no means so common as the two previously described, will be recognized as corresponding to the so-called genus Helminthosporium, or Cladosporium, if we examine before the terminal cells have divided. It is out of the question to give specific names to such forms as those just described, which, since the

publication of Tulasne's "Carpologia Fungorum," are known to be different states of development of species of Pyrenomycetes.

Pycnidia.—Besides the forms already described, there are other bodies of a more complicated nature. Plate 3, Fig. 3, *a*, *a*, represents the *pycnidia*, which are quite numerous in the spots, both on the leaves and the stems. Their general shape is spheroidal. They consist of a membranous sac of the same color as the darker parts of the mycelium, in which are contained the small bodies, which are represented as being discharged in Fig. 3, *b*. Their average diameter is ·04 mm. In general appearance, the pycnidia resemble so closely those with which every one is familiar in other Pyrenomycetes, that any further description is unnecessary.

Stylospores.—In examining the larger black spots on the stems of the olive, other bodies are seen,—the *stylospores*, to adopt Tulasne's nomenclature. They are represented in Fig. 1, *a*, and resemble flasks, whose long necks project beyond the mycelium, by which they are surrounded. They may be recognized by the naked eye, and clearly seen with a hand-lens, as the black projecting necks are tolerably conspicuous. To obtain a good view of them, some of the larger black spots must be picked to pieces, and the fragments treated with caustic potash, and afterwards hydrochloric acid. The shape of the separate flasks is quite variable. The central portion of Fig. 1 represents one of the more regular, where, starting from a somewhat contracted base, there is a regular swelling of the central portion, which again diminishes into a rather long neck of uniform size. In some cases, the flask, instead of being straight, is flexuous with two swellings, the upper one being smaller than the lower. Others, still, fork, and usually one branch is much more obtuse than the other. The size of the flasks varies very much; but, even in their younger states, they can generally be distinguished from the pycnidia by being less inclined to a spherical shape. The height is as variable as the outline. Some of the smaller are ·15 mm. high; others—and they are nearer the average—are ·4 mm. The wall of the flasks is composed of dark-colored cells, which are longer in the direction of the axis of the flasks.

In some cases, the cells, composing the wall of the stylospores, grow outward, so as to form papillæ; and, as the mycelium at the base generally sends up branches around the flask, it is only by a careful dissection that the base can be clearly seen. At first, the mouth is closed, and there is a depression of the cells at the center; but, later, they spring back so as to form, round the open mouth, a circle of slightly reflexed teeth, whose tips are perfectly hyaline. The neck of the flask is hollow: but, in the swollen portion, spores are borne. They are oval, and divided

into four parts by cross partitions. They are not contained in asci, but are attached to short filaments which line the surface of the base and lower portion of the sides of the flask. They escape readily through the open mouth ; and slight pressure on the covering-glass generally causes a fresh discharge.

So far, we have spoken of the fungus as seen on the olive. The orange-leaves sent us are also covered with a black substance, which is not so much in spots as in powdery sheets upon both surfaces of the leaves, more particularly the upper. The attachment to the leaf is by no means as strong as in the olive; and the deposit can easily be scraped off, even without previous moistening. In fact, in some places it falls off on the slightest touch. No specimens of diseased orange-stems were received for examination. A microscopic examination shows why the deposit was more easily removed from the orange than the olive leaves. The smooth surface of the former gives no permanent attachment to the fungus, which, as we have before said, does not penetrate into the interior of the cells of the mother plant; while, on the other hand, the hyphæ wind themselves tightly around the stalks of the stellate hairs of the olive, from which they cannot be removed. If the fungus should attack both oranges and olives, it is very evident why the latter would suffer much more than the former. Apart from the absence of hairs, which invariably constitute a large proportion of the scrapings of the olive-leaves, that from the orange-leaves is precisely identical,—the same moniliform hyphæ, bearing Macrosporium and Helminthosporium spore-like bodies, the same pycnidia and stylospores. Micrometric measurements only confirm the identity. On the orange-leaves sent me, there is a greater proportion of pycnidia, and a smaller proportion of stylospores, than in case of the olive-leaves; but that is, of course, an accidental difference, as the olive-leaves themselves vary. On the orange, the proportion of Helminthosporium-like spores is much greater than on the olive; but, from the facility with which the so-called secondary forms of fruit are produced in fungi, and their great variability, that it is not a fact of any importance; and we can in the most decided manner affirm that the fungus is the same on both plants.

The first account of a fungus growing upon orange-trees, resembling in its habits that received from California, was given by Persoon, in his Mycologia Europæa, p. 10, published in 1822. His description of the new fungus is very briefly given in the following words: "Fumago Citri. late effusa crassiuscula nigro-grisea. Provenit in Europa meridionali ad folia Citri Medicæ, quæ sæpe tota induit." Later, Turpin published an account, with a figure, of a species which he also called Fumago Citri, which Montagne made the type of a new genus, Capnodium,

published in the Annales des Sciences Naturelles, 3 série, tome 11, 1840. Montagne seems to have had doubts as to the identity of the Fumago Citri of Persoon with that of Turpin. Almost simultaneously with the publication by Montagne of his genus Capnodium, Berkeley and Desmazières published, in the Journal of the Horticultural Society of London, vol. iv, p. 252, an article "On some Moulds referred by Authors to Fumago." In this communication, there is the following description of the orange fungus briefly referred to by Persoon and Montagne: "Capnodium Citri, Berk. and Desm. Sparsum, setosum; peridiis elongatis; mycelio ramoso moniliformi pulcherrime reticulato; sporidiis oblongis minutis. Fumago Citri, Pers., Myc. Eur., vol. i, p. 10; Turpin, l. c. On leaves of different species of Citrus. France: Persoon, Léveillé."

Of fungi occurring on olive trees, we have an early account by Montagne in the Annales des Sciences Naturelles, 3 série, tome 12, 1849, of a fungus mentioned in the "Bull. Soc. Centr. d'Agric.," 2 série, iv, p. 267, under the name of Antennaria elæophila, which had been found at Perpignan in 1829, which caused ravages somewhat the same as the California fungus, and which had previously been referred by him to Cladosporium Fumago. It was probably the same plant as the Torula Oleæ of Castagne. Tulasne, however, in the "Carpologia Fungorum," vol. ii, p. 279, showed that the Freiesian genus Antennaria was the pycnidial state of species of fungi of which Capnodium was the ascigerous state. He restored the old name, Fumago, and gave a detailed account of Fumago salicina, which was illustrated in his unrivalled manner.

The fungus from California is evidently the same as that which has been known in Europe since 1829. We have examined two authentic specimens of Antennaria elæophila Mont.,—one from the Duby Herbarium, the other from that of De Notaris, and the structure is precisely that of the pycnidial-bearing portion of the California fungus. The stylospore-bearing portion of our fungus is the Capnodium Citri of Berkeley and Desmazières, to which they refer the Fumago Citri of Persoon and Turpin. Montagne had observed only the pycnidial form—his Antennaria elæophila—on olives; whereas, on the orange, he found only the stylospore form,—his Capnodium Citri. Berkeley and Desmazières make mention only of stylospores on species of Citrus. We have been so fortunate as to find, on the specimens from California, both pycnidia and stylospores, and on both olives and oranges,—which proves the identity of Antennaria elæophila (Mont) and Capnodium Citri (Berk. and Desm.) The perfect ascigerous state of the fungus we have not found; nor do Berkeley and Desmazières seem to have met with it, for they add to their description "asci have not been observed."

We have not been able to find any recorded instance of asci having been found in Capnodium Citri. Tulasne remarks,—quite pertinently, as it seems to us,—that, until better known, Capnodium Citri and Antennaria elæophila can scarcely be considered distinct from Fumago salicina.* The specimens from California certainly seem to strengthen Tulasne's suspicions; and we must confess ourselves quite unable to distinguish between Fumago salicina—found on willows, oaks, birches, hawthorn, quince, and pear—and Capnodium Citri, found on oranges, and, as the Californian specimens show, also on olives. If it be said that no asci have been seen by us, that is no reason why the fungus should be removed from Fumago salicina, which, in the conformation of its mycelium, its conidia, pycnidia, and stylospores, it most closely resembles. Evidently, in the group of fungi which we are considering, too much stress must not be laid on the length and shape of the stylospores. We see, in the specimens before us, how great is the variation in what is undoubtedly a single species. Neither is the fact of the branching of the stylospores very significant, as, in the present case, there are both simple and branching stylospores. If the reader will compare our Plate 3, Fig. 1, with that of *Fumago salicina*, by Tulasne, "Carp. Fung.," Plate XXXIV, Figs. 14 and 20,—leaving out of sight, as far as possible, the different artistic merits of the two,—we think he will admit that, in all essential particulars, they are alike. In reality, the resemblance is even greater than the limited size of our drawing would indicate. We have said that we found no asci; but Plate 1, Fig. 1, *c*, would seem to be the early stage figured by Tulasne, l. c. Fig. 20. The asci will probably be found in California; and we do not doubt that they and their contained spores will prove to be like those of Fumago salicina.

If we seem to the reader to have gone too minutely into the consideration of the systematic position of the fungus, it was for the purpose of bringing out more forcibly the fact that it is nothing new, or peculiar to California; and that it is not even limited to orange, lemon, and olive trees, but, as we have seen, is found on a number of other trees. How does it happen, then, that a fungus so widely diffused should suddenly increase to such an extent as to injure two important crops? We remarked, in passing, that the hyphæ seemed to be, as it were, gummed to the stellate hairs, and, in some cases, to one another, by a sticky substance. We do not forget, that, when any mycelium is growing on a leaf, a certain amount of dirt—including, of course, some oily matter—is sure to be entangled in its meshes. In the

* "Donec melius cognoscantur, a Fumagine salicicola supra descripta ægre etiam discriminantur, nisi sede sibi singulis assueta, tum *Fumago Citri*, Persoonio seu *Capnodium Citri* Montanio; tum etiam *Antennaria elæophila*, Montanio," &c. (Selecta Fungorum Carpologia, pp. 283, 284.)

case of the present fungus, however, there is something more than an accidental accretion of such substances. The surface of the leaves and stems is in many places covered with a gummy deposit, presumably of insect, certainly not of fungus, origin. On this gum, the fungus grows luxuriantly; and, although it may be found on those parts of the leaves where no gum can be seen, yet it is evident that it has reached such places by growing from the gummy spots. Of the origin of the gum, other than that it does not come from the fungus, we have no theory of our own to advance. Remains of insects are abundant on the leaves; but, being entirely ignorant of entomology, we cannot say what their relation is to the diseased trees. It may be that they are stray visitors caught in the gum. The fungus grows most luxuriantly on the remains of insects which I have seen, which, in some cases, present a ludicrous spectacle, the hyphæ projecting from them like the quills of a hedgehog.

It has often been asserted by botanists that fungi, of the group to which ours belongs, are particularly inclined to attack trees which have been previously infested with insects. In 1849, Berkeley, in the London Journal of Horticulture, described a fungus occurring in Ceylon on coffee,—*Triposporium Gardneri*,—which followed the appearance of a species of coccus which was described in the same journal by Mr. George Gardner. In their paper on moulds referred to Fumago, Berkeley and Desmazières make the following statement: "They are often, if not always, preceded by honey-dew, whether arising from aphides, or from a sugary excretion from the leaves themselves. Frequently, too, they are accompanied by some species of coccus, especially in the genus Citrus." Tulasne * does not agree with the writers just mentioned, as will be seen by the reference. He begins his description of Fumago salicina, however, with the following words: "Initio fungillus e membranula constat tenuissima, alba, et hyalina, matricique vivæ instar gummi soluti illitus hæret, quamvis ab eadem, maxime si fortuito ea aruerit, frustulatim aliquando secedat. Id cuticulæ struunt utriculi, perexigui, . . . oleo pallido tandem repleti," &c. This initial stage described by Tulasne is figured in Table XXXIV, Fig. 2, mm., l. c. We must confess that the expression "matricique vivæ instar gummi soluti illitus hæret," seems a little indefinite, but the figure looks

* Quibusdam observatoribus visum est *Fumagines* in fructicibus potissimum provenire quos aphides primum occupassent, tamquam si ex humore dulci quem bestiolæ istæ emittunt, aut ex latice viscido quem matrix ab iis læsa copiosum aliquando stillat, suum pabulum traherent; necessitates autem hujus modi duplici de causa minime verisimiles censemus. Hinc enim sexcenties nobis contigit *Fumagines* luxuriantes videre in arboribus, omnis aphidum generis prorsus expertibus; illinc *Fumagines* vere parasitari constat, succis scilicet alienis uti ex his vivis. Super hoc argumento conferas tamen quæ attulit Berkelæus in tomo iv. (1849) Ephemeridis Soc. Hortic. Londinensium, nec non Georgio Gardner commentatiunculam ibidem (pp. 1–6) editam circa the Coffee-bug and Coffee-mildew. (Carp. Fung., ii, p. 280.)

exceedingly like a collection of oil-globules, or very small eggs. We do not pretend to say that what Tulasne saw was not a membrane of vegetable substance,—a part of the fungus itself; but, in the Californian specimens, we had something which looked very much like the mm. of Tulasne's figure, and, in this case, we have satisfied ourselves, by observation and experiment, that it is of animal nature, and not a part of the fungus, which, instead, was growing upon it. It is a little difficult to understand, from what is already known of the developement of fungi, how any fungus could begin as a very thin membrane, composed of small cells filled with oil. The initial stage of fungi, if we except the Myxomycetes, as far as we know, is filamentous, not membranous.

The result of our examination of the diseased orange and olive leaves is briefly as follows: The disease, although first attracting the eye by the presence of a black fungus, is not caused by it, but rather by the attack of some insect, which itself deposits some gummy substance on the leaves and bark, or so wounds the tree as to cause some sticky exudation, on which the fungus especially thrives. It is not denied that the growth of the fungus greatly aggravates the trouble already existing, by so encasing the leaves as to prevent the action of the sunlight; we only say, that, in seeking a remedy, we are to look further back than the fungus itself,—to the insect, or whatever it may be, which has made the luxuriant growth of the fungus possible. With regard to the fungus, we are able to assert that it is the same on both olives and oranges,—the species described by Berkeley and Desmazières under the name of *Capnodium Citri*, which seems to us, together with the pycnidial state described by Montagne under the name of *Antennaria elæophila*, to be but two states of a species identical with that described by Tulasne as *Fumago salicina.* It remains yet to find the asci on olives or oranges, which will probably be accomplished without difficulty in California. The earliest stages of the fungus should be studied by some one living near orange groves; for, although the disease has been known to attack greenhouse plants, it is not very common, or, in that case, so favorable for study. Especially is it to be desired that careful notes of the extent and manner of appearance of the disease, and the climatic and hygrometric conditions attending it, should be carefully recorded.

As a remedy, alkaline soaps, as strong as the trees will bear, will no doubt prove advantageous in case of the oranges; but, in the case of the olives, much less good is to be expected, owing to the presence of the stellate hairs on leaves and twigs. With this, our notice of the disease from a botanical stand-point ends; and we commend the subject to the attention of entomologists.

ART. VII.—*On the Reaction of Sulphuric Acid upon Tri-calcic Phosphate*; by H. P. ARMSBY.

THE following experiments were undertaken to ascertain the influence of temperature and time on the reaction between one molecule of sulphuric acid and one of tri-calcic phosphate.

The materials employed were precipitated tri-calcic phosphate and a solution of sulphuric acid containing in 1 c.c., 0·8784 grms. H_2SO_4.

The tri-calcic phosphate was prepared by precipitation from an ammoniacal solution of calcium chloride by di-sodic phosphate, the precipitate being washed with cold water. An analysis gave:—

Ca	33·73 per cent.
PO_4	53·82 " "
H_2O	not determined.

Although washed by decantation till the washings gave no precipitate with silver nitrate the substance still contained traces of soluble phosphoric acid, probably as phosphate of soda.

The experiments were conducted as follows: a weighed quantity (generally about five grms.) of tri-calcic phosphate was mixed by rubbing in a mortar with the equivalent quantity of sulphuric acid, and treated as follows:—

I.	Stood	2½	hours	at 100° C.		
II.	"	"	"	"	ordinary	temperature.
III.	"	"	"	"	"	"
IV.	"	½	hour	"	"	"
V.	"	5	minutes	at	"	"

The mixture was then washed with cold water till the washings ceased to show an acid reaction, the filtrate diluted to 500 c.c. and in it lime, phosphoric acid, and sulphuric acid determined. The composition of the insoluble portion was in some cases determined directly, and in others by difference. In calculating the results, the sulphuric acid of the aqueous solution was combined with lime, the residue of the lime with phosphoric acid to mono calcic phosphate, and the remainder of the phosphoric acid was considered as free. A portion of it at least may have been the soluble phosphoric acid of the tri-calcic phosphate. In the insoluble portion the sulphuric acid was also combined with lime, and the remainder of the lime with phosphoric acid, the excess of the latter over that required to form tri-calcic phosphate being considered to exist as the only other insoluble compound, viz., di-calcic phosphate. The following table gives the results calculated on ten grams of $Ca_3(PO_4)_2$.

APPLIED.	I.	II.	III.	IV.	V.
$Ca_3(PO_4)_2$	10·000 grms.	10·000 grms.	10·000 grms.	10·000 grms.	10·000 grms.
H_2SO_4	3·143 "	3·748 "	3·209 "	3·209 "	3·209 "
FOUND, soluble.					
$CaSO_4$	2·124 grms.	2·459 grms.	2·960 "	1·140 grms.	
$CaH_4(PO_4)_2$	·837 "	1·277 "	1·334 "	·850 "	3·562 grms.
H_3PO_4	·309 "	·343 "	·152 "	·448 "	
Insoluble.					
$CaSO_4$	2·168 grms.	2·784 grms.	1·504 grms.	3·466 "	
$CaHPO_4$	6·467 "	6·120 "	5·415 "	5·493 "	
$Ca_3(PO_4)_2$	1·065 "	·803 "	1·899 "	1·947 "	

It will be seen that the amount of di-calcic phosphate increases and that of mono-calcic phosphate decreases the longer the mixture stands and the higher the temperature to which it is exposed.

The following table shows the decrease of mono-calcic phosphate still more clearly.

If the reaction take place according to the equation

$$Ca_3(PO_4)_2+2H_2SO_4=CaH_4(PO_4)_2+2CaSO_4$$

one molecule of sulphuric acid should render soluble one molecule, or its own weight, of phosphoric acid. The fourth line of the table gives the per cent of this theoretical quantity which was actually found.

	I.	II.	III.	IV.	V.
Applied, $Ca_3(PO_4)_2$	2·784 grms.	2·972 grms.	4·377 grms.	4·377 grms.	4·377 grms.
" H_2SO_4	·875 "	1·113 "	1·405 "	1·405 "	1·405 "
Found H_3PO_4	·282 "	·420 "	·555 "	·507 "	1·305 "
% of theoret. H_3PO_4	32·2 %	37·7 %	39·5 %	36·1 %	92·8 %

In order to be sure that these differences were not due to incomplete washing a second set of experiments was made with smaller quantities. The tri-calcic phosphate was mixed with water to a thin paste, the sulphuric acid added, the mixture well stirred, and treated as follows:—

I. Stood 3 hours at 100° C.
II. " " " " ordinary temperature.
III. " ½ hour " " "
IV. " 5 minutes at " "

It was then filtered on the pump, washed with cold water till the washings showed only a very faint reaction for phosphoric acid with magnesia mixture, the filtrate diluted to 500 c.c. and in 50 c.c. the phosphoric acid determined by the molybdic method.

	I.	II.	III.	IV.
Applied, $Ca_3(PO_4)_2$	1·751 grms.	1·751 grms.	1·751 grms.	1·751 grms.
" H_2SO_4	·438 "	·438 "	·438 "	·438 "
Found, H_3PO_4	·172 "	·200 "	·209 "	·415 "
% of the theoretical H_3PO_4	39·2 %	45·6 %	47·7 %	94·7 %

To ascertain the extent of error from incomplete washing the insoluble portion of I. was further washed with about 250 c.c. of cold water and the phosphoric acid in the filtrate determined. Its amount was 0·013 grms. a part of which was doubtless due to di-calcic phosphate which is slightly soluble in water, though not sufficiently so to introduce any material error into the experiments.

From the above results it appears that the reaction between sulphuric acid and tri-calcic phosphate, when the two are present in the proportion of one molecule of each, passes through two stages.

1st. The sulphuric acid reacts on half the tri-calcic phosphate, producing mono-calcic phosphate. Whether free phosphoric acid is at first produced cannot be determined from these experiments, but if it is, it must quickly disappear.

2d. The mono-calcic phosphate thus produced reacts more slowly on the other half of the tri-calcic phosphate in the manner described by Piccard (Zeitschr. für Chemie, ix, 545), producing di-calcic phosphate,

$$CaH_4(PO_4)_2 + Ca_3(PO_4)_2 = 4CaHPO_4.$$

A high temperature appears to favor the reaction.

Chemical Laboratory of the University of Leipzig, March, 1876.

ART. VIII.—*Dr. Vogel's Color Theory*; by M. CAREY LEA, Philadelphia.

WHEN Dr. Vogel first endeavored to establish the existence of a relation between the color of substances modifying the sensitiveness of silver bromide and the refrangibility of the rays to which that sensitiveness was increased, I made a two-fold objection. First, that no sufficient proof had been given that in any one instance a colored pigment had increased the sensitiveness to the rays which it absorbed. Second, that many substances altogether colorless conspicuously increased the sensitiveness to particular rays. To this last objection Dr. Vogel replied that because substances were colorless, it did not follow that they acted equally upon the different rays.

To give this answer weight, it should have been accompa-

nied by proof that some of these colorless substances showed a power of absorbing the rays to which they increased the sensitiveness of silver bromide. No such proof was given. Although scarcely called upon to prove a negative, yet desiring to leave no side of this question unexamined, I have recently subjected to careful spectroscopic examination those colorless substances which I have described as distinctly increasing the sensitiveness of silver bromide to green light.

This examination was made with a table spectroscope furnished with an exterior prism to throw light from a second source of illumination upon the slit, in order to obtain two adjacent spectra. The solution being then interposed in the path of one set of rays, the spectrum influenced by it is seen side by side with a complete spectrum, and the slightest changes are made evident. For greater exactness the glass vessel was first filled with water and interposed, then the argand burners used were moved to such distances as to make the two spectra exactly equal in intensity. In the examination, the size of the slit was varied from that which barely gave a visible spectrum, up to such as gave a powerful illumination, and the comparison was made with all intensities, though of course the faint illuminations gave the most critical tests. The substances examined were potassic arsenite, codeia, salicine and morphia acetate. All of these substances, as I have elsewhere shown, exhibit a marked power of increasing the sensitiveness of silver bromide to the green rays.

No elective absorption could be detected in any of them. It is therefore certain that *their capacity to increase the action of the green ray is independent of any power to absorb that ray.*

Certainly if a law such as enunciated by Dr. Vogel existed, there ought to be found, without difficulty, very many substances which would exemplify it. On the contrary Dr. Vogel has named very few cases in which he has recorded results conforming to his hypothesis. Indeed his hypothesis has seemed to rest chiefly upon three substances, coralline, chlorophyll, and naphthaline red.

I have very carefully examined the action of all three of the substances with the following results:

Coralline, as I have before said, enhances the sensitiveness more to the color which it chiefly transmits, red, than to those which it absorbs. Moreover its power of increasing sensitiveness (at least as far as the green rays are concerned) may be destroyed by the addition of a trace of weak acid, so that while its color remains, its action is destroyed. Coralline therefore does not afford any support to the theory, but rather the contrary.

Chlorophyll is perhaps the only substance that corresponds to some extent in its action with the demand of the theory. Some chlorophyll, which I prepared from ivy leaves, had a bright green color in solution; it diminished the action of silver bromide to the green rays, and increased it to the red. It should be said however that the support given by this substance is very much qualified by its peculiar absorption spectrum.

Naphthaline red has been cited by Dr. Vogel as affording by its action a powerful confirmation of his views. It has not done so in my hands.

When a not too strong solution is examined in the spectroscope, it is found to allow all the red and yellow rays to pass up to the limit of the green, where the transmission stops. Dr. Vogel affirms that the naphthaline red increases sensitiveness to the *yellow* rays, using it in not too strong solution. But it is certain that this substance unless it is used in very strong solution, allows the yellow rays to pass freely, stopping only the green and the rays beyond the green. It appears, therefore, that a dilute solution of naphthaline red *does not absorb* the yellows rays, to which, according to Dr. Vogel, it increases sensitiveness. And again the result of experiments made by myself with the green rays, which it does undoubtedly absorb, is that it not only does not increase sensitiveness to them, but actually diminishes it.

I therefore conclude that up to the present time no proof of the correctness of this theory has been found, but, on the contrary, a vast array of facts that are irreconcilable with it.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the true Ethyl Sulphate.*—By acting on ethyl alcohol or ether by sulphuric acid, Wetherill obtained a neutral body which has been regarded since that time as the true sulphuric ether, $SO_2\left\{\begin{matrix}OC_2H_5\\OC_2H_5\end{matrix}\right.$. Later Baumstark obtained a substance by acting on alcohol by sulphuric oxychloride, which he supposed identical with Wetherill's ether, but which Max Müller regarded as an isomer of it, ethyl oxyethansulphonate; $C_2H_4\left\{\begin{matrix}OH\\SO_2OC_2H_5\end{matrix}\right.$. Mazurowska has prepared anew this latter compound, and has examined it more thoroughly. It appears as a yellowish, odorless, neutral liquid, of syrupy consistence and having a sp. gr. of 1·24. It dissolves readily in water, decomposing and becoming acid. Heated above 100° it carbonizes. Analysis gave it the formula

$(C_2H_5)_2SO_4$. Decomposition by water gave sulphethylic acid, the barium and potassium salts being prepared and analyzed. Methyl, propyl, butyl, and amyl alcohols yielded similar ethers, having analogous properties and forming a regular series. Wetherill's ether, however, is markedly different in its properties. It is an oily, colorless liquid, with an odor like peppermint, of sp. gr. 1·12, and which can be distilled, oily drops passing over at 110° to 120°. To ascertain which of these bodies was the true ether, the ethers themselves as well as the acids derived from them, were treated with potassium sulphydrate. In this way, Baumstark's body was proved to be the true ethyl sulphate, Wetherill's being its isomer as above. Similar ethers were obtained with phenol, nitro-phenol and thymol.—*J. pr. Ch.*, II, xiii, 158, March, 1876. G. F. B.

2. *Anthraflavic and Isoanthraflavic acids.*—SCHUNK and ROEMER have detected in crude artificial alizarin a new acid, isomeric with anthraflavic acid discovered by the former chemist in 1871. To obtain it the crude alizarin is treated with lime water and the red solution decomposed with hydrochloric acid. The precipitate is dissolved in dilute soda solution, again precipitated, dissolved in baryta water, and thrown down a third time. The yellow or green flocks crystallize from alcohol in yellow needles, sometimes in gold-yellow brilliant plates. Analysis of the substance dried at 150° gave the formula $C_{14}H_8O_4$; the crystals have a molecule of water. The salts of the new acid were prepared and analyzed, and compared with those of anthraflavic acid. These as well as the substitution derivatives showed marked differences between the two bodies. Both, it should be remembered, are isomeric with alizarin.—*Ber. Berl. Chem. Ges.*, ix, 378, March, 1876. G. F. B.

3. *On Sulphonaphthalide.*—CLEVE has examined the substance obtained by Berzelius in 1837 by the action of sulphuric acid on naphthalene, and which he called sulphonaphthalide. Crystallized from absolute alcohol, it appears in perfectly white needles, often some centimeters long. It melts at 175·5°, is insoluble in water, difficultly so in alcohol and ether, very soluble in benzene. Analysis gives it the formula $C_{20}H_{14}SO_2$, or $SO_2\left\{\begin{matrix}C_{10}H_7\\C_{10}H_7\end{matrix}\right.$. Heated with phosphoric chloride and with ammonia, it yields a mixture from which ether extracts a solid body β-chloronaphthalene, $C_{10}H_7Cl$, leaving, behind the amide of β-naphthylsulphurous acid, the chloride being $C_{10}H_7SO_2Cl$.—*Bull. Soc. Ch.*, II, xxv, 256, March, 1876. G. F. B.

4. *Evolution of Hydrogen by the action of Zinc upon neutral Copper sulphate.*—For the preparation of a considerable quantity of finely divided copper by Schiff's method, LOTHAR MEYER heated to 60° C. a mixture of copper sulphate crystals, metallic zinc and water, and observed a rapid evolution of pure hydrogen, a fact noted in 1840 by Leykauf. Further experiments showed that the evolution of hydrogen takes place at ordinary tempera-

tures, but is very slow, continuing for months. The resulting solution contains only normal zinc sulphate, no basic salt being present. A dark gray powder is deposited, however, which consists of basic zinc sulphate and copper. It appears therefore that the copper in this reaction is not simply exchanged for zinc, atom for atom, but that some of the copper is replaced by hydrogen. This, giving hydrogen sulphate, is acted on by the zinc, evolving hydrogen.—*Ber. Berl. Chem. Ges.*, ix, 512, April, 1876. G. F. B.

5. *Decomposition of Ammonium nitrate by heat.*—BERTHELOT has studied the decomposition of ammonium nitrate by heat. He finds that this salt melts at about 152° C., but that no appreciable quantity of gas is evolved below 210°. The rapidity of the evolution increases uniformly with the rise in temperature up to 300°, and then, if the fire be urged, the mass explodes. These characters are those of an exothermic decomposition and sustain the results of the author's calorimetrical experiments, according to which the production of the hyponitrous oxide theoretically disengages, in the reaction $NH_4NO_3=N_2O+(H_2O)_2$, about +46 calories. The volume of gas obtained, however, is always less than that indicated by theory, owing to the volatility of the ammonium nitrate itself. Indeed this salt may even be sublimed without decomposition by placing it, previously melted, in a capsule covered with paper, and over which is a card-board cylinder filled with fragments of glass. The capsule is placed in a sand bath and heated to 190° to 200°; the sublimed salt attaches itself in brilliant crystals to the sides of the capsule and the paper cover, a portion also passing through and covering the glass. Its composition was verified by analysis. That this is not a dissociation into ammonia and nitric acid is shown by the fact that the paper is not attacked.—*C. R.*, lxxxii, 932, April, 1876. G. F. B.

6. *Additional facts concerning Gallium.*—BOISBAUDRAN, the discoverer of gallium, has presented to the Academy a specimen of what he believes to be the nearly pure metal. The specimen weighed about one decigram and was extracted from 431 kilograms of the crude material. Unlike the specimen first made, and which was solid owing to impurities, the author finds pure gallium to be essentially a liquid metal, since it melts at 29·5°, and is therefore easily liquefied between the fingers. It exhibits markedly the phenomenon of surfusion, a globule remaining liquid for weeks, during which time the thermometer may go down to zero. Once solidified, the metal is hard and resistant; though easily cut and somewhat malleable. When melted it adheres strongly to glass forming a whiter mirror than mercury. Heated to redness in the air, it oxidizes only superficially and does not volatilize. It is not sensibly attacked by cold nitric acid. Its density is 4·7 at 15°. Deposited on platinum by electrolysis from solution in ammonium or potassium hydrate, it presents a grayish-white mat surface, formed of minute globules. Cold dilute hydrochloric acid dissolves it, disengaging hydrogen; but the residue obtained by evaporating this solution, is not colored by potassium

iodide, ammonia, or ammonium sulphydrate.—*C. R.*, lxxxii, 1036, May, 1876. G. F. B.

7. *Metallic Cerium, Lanthanum, and Didymium.*—Drs. HILLEBRAND and NORTON, in Bunsen's laboratory, have obtained, by the electrolysis of the cerium, lanthanum and didymium chlorides, the metals in quantities sufficient for careful investigation. As proof of the purity of the materials employed they refer to the methods of separation given by Bunsen (Pogg. Ann., clv, 366). Metallic cerium has the color and luster of iron; it slowly tarnishes in dry air and in moist air soon changes color, as steel does when heated, to yellow, blue, and gray. After fusion it has the hardness of calcite, and is malleable and very ductile. The specific gravity of the electrolytic metal is 6·628, and after fusion under salt and potassium chloride it is 6·728. The low specific gravity found for cerium reduced by sodium 5·5 indicates that it contained sodium. The melting point of cerium is lower than that of silver and considerably higher than that of antimony. Its kindling temperature in air and oxygen is much lower than that of magnesium. Pieces scratched off inflame, and the wire ignited in a flame burns more brilliantly than magnesium wire. It burns when heated in chlorine, less readily in bromine vapor, and without incandescence in iodine vapor. Water at common temperatures is slowly decomposed by it; cold concentrated sulphuric acid and cold red fuming nitric acid do not attack it, but these acids when dilute, and also hydrochloric acid, dissolve it. Metallic lanthanum is much like cerium in its general chemical deportment, but by concentrated nitric acid it is easily attacked. It is slightly harder and less ductile than cerium; it is less permanent in air, and even in dry air its color soon changes to a steel blue. The specific gravity of a piece deposited by electrolysis weighing 7·6 grams was 6·163; after fusion it was less, 6·049. Its melting point appears to be near that of cerium, and its kindling temperature is higher. Small pieces from filing or striking on flint do not ignite spontaneously in the air, but burn brilliantly in the flame. Their analysis shows less than one per cent of impurity in the specimen.

Metallic didymium is more like lanthanum than cerium; it is not less lustrous, ductile or permanent in air than lanthanum, and has about the same hardness; its color is not as white, and moist air turns it yellow. Fine particles of the metal do not ignite spontaneously in the air, but burn when heated in a lamp flame. It is less fusible than either lanthanum or cerium, and the metal after fusion has a specific gravity of 6·544.—*Pogg. Ann.*, clv, 633, Aug., 1875. G. F. B.

8. *On Gentisin.*—HLASIWETZ and HABERMANN have published a second paper on Gentisin, a crystallized non-nitrogenous body obtained from gentian root (*Gentiana lutea*). In their previous paper they showed that under the influence of alkali hydrates, gentisin splits up into phloroglucin $C_6H_6O_3$ and an acid of the formula $C_7H_6O_4$, to which they gave the name gentisic acid.

Under the action of heat, this latter body loses carbon dioxide and yields a neutral body of the composition $C_6H_6O_2$, provisionally called pyrogentisic acid. They now find that this last substance is identical with hydroquinone, the true melting point of which is 169°, and that gentisic acid is identical with oxysalicylic acid, which fuses at 196° to 197°. From its reactions therefore the authors give to gentisin the rational formula

$$\begin{array}{l} C_6H_2 \left\{ \begin{array}{l} CH_3 \\ O> \\ O> \end{array} \right. \\ \;| \\ CO \\ \;| \\ C_6H_3 \left\{ \begin{array}{l} OH \\ OH \end{array} \right. \end{array}$$

and suppose that it is formed from an isomer of piperonal united to phloroglucin, thus:

$$C_6H_2 \left\{ \begin{array}{l} CH_3 \\ O> \\ O> \\ CO\,H \end{array} \right. + C_6H_3 \left\{ \begin{array}{l} OH \\ OH \\ OH \end{array} \right. - H_2O = \begin{array}{l} C_6H_2 \left\{ \begin{array}{l} CH_3 \\ O> \\ O> \end{array} \right. \\ \;| \\ CO \\ \;| \\ C_6H_3 \left\{ \begin{array}{l} OH \\ OH \end{array} \right. \end{array}$$

Hence when it is fused with alkalies, it acts thus:—

$$\underset{\text{Gentisin.}}{(C_{14}H_{10}O_5)_2} + O_2 + (H_2O)_4 = \underset{\text{Phloroglucin.}}{(C_6H_6O_3)_2} + \underset{\text{Oxysalicylic acid.}}{(C_7H_6O_4)_2} + \underset{\text{Acetic acid.}}{C_2H_4O_2}$$

—*Liebig's Annalen*, clxxx, 343, March, 1876. G. F. B.

9. *On the milky juice of an Asclepiad, Cynanchum acutum.*—BUTLEROW has examined the milky juice of Cynanchum acutum, brought from the Oxus by the Russian Geographical Society's Expedition. The plant is a climber and is regarded as poisonous, especially to camels. The juice contained a volatile non-poisonous alkaloid, and the aqueous portion was rich in potassium chloride, but contained no sodium though grown on a soil rich in that substance. Below the aqueous portion was a white coagulum, which fused by heat and evolved an odor like that from burning rubber. It was extracted with boiling alcohol and then with carbon disulphide. The latter left on evaporation a transparent yellow resin. The alcoholic solution deposited warty grains on cooling, which when purified crystallized in needles. On analysis this body gave the formula $C_{15}H_{24}O$, and as it appears analogous to the phenols in its properties, the author gives it the name cynanchol; the asclepion of List being an impure variety.—*Liebig's Ann.*, clxxx, 349, March, 1876. G. F. B.

10. *On Amidines of Monobasic Acids.*—The name amidine was given first by Wallach to a class of organic bases of the general formula $R.C \left\{ \begin{array}{l} NR'' \\ NR'_2 \end{array} \right.$ derived from amides $R.C \left\{ \begin{array}{l} O \\ NR'_2 \end{array} \right.$ by exchanging O for $(NR)''$. As R represents either hydrogen or a hydrocarbon radical, it is evident that a series of bases may be formed from the amide of any acid in this way. Thus from acetamide

$CH_3C\left\langle\begin{array}{l}NH_2\\O\end{array}\right.$	$CH_3C\left\langle\begin{array}{l}NHC_2H_5\\O\end{array}\right.$	$CH_3C\left\langle\begin{array}{l}NHC_6H_5\\O\end{array}\right.$	we have
Acetamide.	Acetethylamide.	Acetanilide.	
$CH_3C\left\langle\begin{array}{l}NH_2\\NH\end{array}\right.$	$CH_3C\left\langle\begin{array}{l}NHC_2H_5\\NC_2H_5\end{array}\right.$	$CH_3C\left\langle\begin{array}{l}NHC_6H_5\\NC_6H_5\end{array}\right.$	
Acediamine (the amidine of acetamide).	Ethenyl-diethylamimide.	Ethenyldiphenylamimide.	

In the same way, guanidine is the amidine of carbamide or urea. Under the influence of water the acid amides are regenerated. BERNTHSEN has examined several new bodies of this class, phenyl-acetamimide $C_6H_5-CH_2-C\left\langle\begin{array}{l}NH_2\\NH\end{array}\right.$, its mono-phenyl and mono-tolyl derivatives, benzenyl-monophenyl-amimide,

$$C_6H_5-C\left\langle\begin{array}{l}NH_2\\NC_6H_5\end{array}\right.,$$

and the diphenyl, mono- and di-tolyl derivatives.—*Ber. Berl. Chem. Ges.*, viii, 1575; ix, 429, March, 1876. G. F. B.

11. *On Fermentation;* by P. SCHÜTZENBERGER. [International Scientific Series. D. Appleton & Co., New York.]—This volume, although rather too technical for the general reader, gives to the student in a convenient form a *résumé* of the early and of the most recent researches on fermentation (alcoholic, lactic, butyric, etc.), and is a valuable addition to the International Scientific Series, of which it is the third volume on chemical subjects. The aim and plan of the International Scientific Series has already been alluded to in this Journal (vol. v, p. 241, 1875). It is not our purpose in the present instance to criticize the subject matter of the volume before us, but to call attention to some of the shortcomings of the English version.

The most serious error is, perhaps, the translation of "*matières hydrocarbonées*" by "hydrocarbons." On page 65 and following, and throughout the book sugar, cellulose and starch are spoken of as "hydrocarbons!" A mistake scarcely less serious occurs in the description of Schützenberger's process for determining dissolved oxygen (pages 108 and following). Here Schützenberger's "hydrosulphurous acid" and "hydrosulphite" are rendered, very properly, "hyposulphurous" and "hyposulphite," but no note or comment (except the symbol) tells us that the sodium hyposulphite thus indicated is not the common "hyposulphite of soda" which still in the arts and indeed generally bears the old name. On other pages hyposulphite is used in its former sense (instead of "thiosulphate" or other name). It would therefore seem that the mistake arose from ignorance or carelessness on the part of the translator.

Among other less important blunders it may be said that "*poudre de zinc*" is not "powdered zinc" but zinc dust (zinc-staub); Sterry Hunt regarded the albuminoids as "nitriles" not

as "nitrites" (and as this mistake occurs in several places it can hardly be a printer's error); "*étant ramenée*" (page iii) should be rendered "reduced" and not "brought back," as it is a question of converting a cupric to a cuprous compound for the first time.

In a prefatory note the translator deliberately chooses to render "*invertir*," "*inverti*," etc. by "alter," "altered," etc., instead of the much more familiar "invert," "inverted," etc. It is probably also to the choice of the translator that we owe the terms "potass," "hydratation," "dishydratation," "magnesium subcarbonate," and "marine salt."

We may pass over various misprints, mentioning one only, by which a paragraph headed in the original "*Gaz Lumière*" appears with the heading "Gas-light" to the confusion of the reader. We may, however, criticize the constant use of the French words, with accents, to indicate the weights and measures of the metric system, and also the giving in every case the equivalent in English weights and measures (often to the third place of decimals) even where an approximate or relative number is mentioned. As a single instance, we read on page 111, "about 1 cub. centimètre of oxygen (·061 cub. in.) for each 10 cub. cent. (·61 cub. in.) of the solution."

It is most certainly to be hoped that the promised volumes of Wurtz, H. SteClaire Deville, and Berthelot will not suffer such treatment at the hands of translators as have Vogel and Schützenberger. As far as the reader is concerned, it is at present safer to procure the works in the original tongues; and thus one promise of the *International Series* fails to be fulfilled. W. R. N.

12. *Liquid Films.*—Dr. SONDHAUSS has extended the observations of Plateau on liquid films to the determination of the extent to which different liquids can be stretched in wire rings. He observed the lamellæ in closed vessels excluding external disturbances, measured with a balance their tension and with a manometer the pressure of bubbles on the enclosed air; he also measured the weight of such lamellæ and bubbles, whence their thickness might be inferred. With a simple contrivance consisting of a thin wire bent horizontally to an angle, and a straight wire placed across and drawn gradually away from the angle, it may be shown that all liquids may be stretched in lamellæ, and that different liquids may be compared in this respect. But Dr. Sondhauss prefers the circular wire rings, and compares (as to size) the films of forty-six different liquids. One film from a guillaja decoction, to which a little glycerine had been added, lasted over half a year.—*Nature*, xiv, 37. E. C. P.

13. *Law of Refraction.*—Prof. FOSTER, at a recent meeting of the Physical Society, exhibited and described an instrument for illustrating the law of refraction. It is founded on the well-known method of determining the direction of the ray after refraction by means of two circles described from the point of incidence as a center, the ratio of whose radii is the index of refraction. If the incident ray is projected to meet the inner circle, and through the point of intersection a vertical line be drawn, the line drawn from

the point of incidence to the point where this meets the outer circle is the direction after refraction. This principle is applied in making a self-adjusting apparatus as follows: A rod representing the incident ray is pivoted at the point of incidence, and projects to a point about four inches beyond. To its extremity is attached a vertical rod which slides through a nut in another rod also pivoted at the point of incidence. The lower extremity of the vertical rod is attached to a link, so fixed as to constrain it to remain vertical. By this means the two rods always represent respectively the incident and refracted rays, and the index of refraction can be varied by altering the position of the nut, through which the vertical rod passes, on the rod to which it is attached.—*Nature*, xiii, 535. E. C. P.

14. *Magnifying Glass.*—Mr. JOHN BROWNING has recently contrived a new form of simple magnifier which is thus described: The platyscopic lens is a triple combination, in which the chromatic and spherical aberrations are corrected by a central lens of dense glass. This lens is nearly three times as thick as the crown-glass lenses. The interior curves are almost hemispheres. The final correction for spherical aberration is made by altering the thickness of the dense glass lens. The three lenses are united by a transparent cement which has an index of refraction corresponding very nearly with that of glass. This prevents light being lost by reflection from the surface of the deep curves. The platyscopic lens is made of three powers magnifying respectively 15, 20 and 30 diameters. It possesses the convenience of the Coddington lens while its freedom from chromatic and spherical aberration renders its definition vastly superior. Its working distance is also much greater than that of any lens of equal magnifying power. This is very perceptible in the smallest of the series which gives so much space that opaque objects can be viewed with the greatest facility—an important matter to naturalists in field observations. A very good view is also obtained through water. Owing to the perfect corrections the internal diaphragm of the Coddington lens is not needed, causing a vast increase of light.—*Quart. Journ. of Sci.*, l, 284. E. C. P.

15. *New Electro-Magnet.*—M. V. SERRIN calls attention to the difficulty experienced with powerful electric lights from the heating of the magnets in their regulators. The effect of this is to burn the insulating material and destroy the effect of the magnet by short circuiting it. This difficulty is avoided by a metallic helix with no insulating covering and so formed that the spires cannot touch. The helices are made of copper cylinders of a thickness equal to that of the bobbin. The cores are then covered with a vitreous enamel. The construction of these helices presents no especial difficulty and has the advantages of beauty and that it is easily taken to pieces. The cross-section is such that the metal is not heated perceptibly to the touch with even a powerful Bunsen battery, while it may be heated to redness without undergoing sensible change or losing its efficiency. Some further improvements have been introduced into the regulator so that the luminous point may be moved without extinguishing it, a mat-

ter of great importance in light-houses. In the model the carbons are 15mms. on a side and yet notwithstanding their large size the sensibility of the apparatus is so great that a small ring of rubber placed between the two carbons is capable of arresting the motion without undergoing a sensible change in form.—*Comptes Rendus*, lxxxii, 1054. E. C. P.

16. *Electro-magnetic Rotations.*—Mr. W. SPOTTISWOODE in a recent communication to the Royal Society discusses the phenomenon known as the rotating spark. A powerful magnet being brought near the spark the latter is seen to assume a spiral form which is right-handed or left-handed according to the direction of the current and of the magnetic polarity. The spark was passed between the poles of an electro-magnet and the effect on the form of the discharge caused by exciting the magnet was observed. For this purpose the movable poles were insulated from the main body of the magnet by interposing a sheet of ebonite thick enough to prevent the passage of the spark.

The discharge, as is well known, consists of two parts, the spark proper and a bright cloud or flame surrounding it which may be thrown to one side by a current of air. The spark is but little affected by the magnet, but the flame is at once spread out into a sheet forming a right or left handed helicoid according to the direction of the current, and following Ampère's law. Similar effects were obtained with other gases and at other pressures. The brilliancy may be increased by attaching a piece of sodium to the negative terminal, or by causing a stream of any of the volatile chlorides to flow across the field of action. The following explanation is due to Prof. Stokes. Supposing the magnetic field to be uniform, the lines of force will be straight lines from pole to pole. In such a condition everything being symmetrical, no rotation would take place. But if through any local circumstance the path of the current be distorted or displaced, then each element will be subject to two forces, one tending to turn the current around the axis, the other tending to make it follow the shortest path so as to diminish the resistance.

The general nature of the phenomenon may be described as follows: First, we have the bright spark of no sensible duration which strikes nearly in a straight line between the terminals. This opens a path for the continuous discharge which being nearly in a condition of equilibrium, though an untranslatable one, remains a short time without much change of place. Then it moves rapidly to its position of equilibrium, the surface which is its locus forming the sheet. Then it remains in its position of equilibrium during the greater part of the discharge, approaching the axis again as the discharge falls, so that its equilibrium position is not so far from the axis. Thus we see two bright curves corresponding to the two positions of approximate rest united by a less bright sheet; the first curve lies nearly in a straight line and the second nearly in a helix traced on a cylinder of which the former line is a generating line. The appearance of the discharge when viewed in a revolving mirror confirms the above remarks.—*Nature*, xiii, 698. E. C. P.

II. Geology and Mineralogy.

1. *Recent Discoveries of Extinct Animals by Professor Marsh.*—In a lecture to the Graduating Class of Yale College, delivered in the new Peabody Museum, June 3d, Professor O. C. Marsh gave a brief *résumé* of the more important results of his late paleontological researches in the Rocky Mountain region. His explorations, which were attended with much hardship and danger, have been mainly confined to the Cretaceous and Tertiary formations, and especially to their vertebrate fauna. During the past six years, the expeditions under his charge have brought to light more than 300 species of fossil vertebrates new to science, about 200 of which he has already described.

Among the extinct animals thus discovered, were many new groups, representing forms of life hitherto unknown. The most interesting of these are the Cretaceous *Odontornithes*, or Birds with teeth, which constitute a new sub-class, containing two distinct orders, viz: the *Odontolcæ*, which have the teeth in grooves, and the *Odontotormæ*, with teeth in distinct sockets. The former were swimming birds of gigantic size, with rudimentary wings, and the vertebræ as in modern birds. The type genus is *Hesperornis*, and three species are known. The second order embraces at present only small birds with powerful wings, and biconcave vertebræ. The type genus is *Ichthyornis*, and the geological horizon is upper Cretaceous. Another discovery of importance from the same formation was Pterodactyls, or flying reptiles, the first detected in this country. These are of much interest, on account of their enormous size,—some having a spread of wings of more than twenty-five feet,—but especially as they were destitute of teeth, and hence resembled recent birds. They form a new order, *Pteranodontia*, from the typical genus *Pteranodon*, six species of which are now known. With these fossils were found large numbers of Mosasauroid reptiles, and remains of more than 500 different individuals were collected. These proved to belong to two new families, *Tylosauridæ* and *Edestosauridæ*. Some of the former attained a length of sixty feet, while the latter were much shorter, the smallest being less than ten feet. These groups included several new genera and many species. This large series of specimens enabled Professor Marsh to clear up many doubtful points in the structure of these reptiles, and to determine that they possessed hind paddles, and were covered, in part at least, with bony dermal scutes. Many other Birds, Reptiles and Fishes were found in the same Cretaceous strata.

The discoveries of Professor Marsh and party in the Tertiary of the West were of no less importance. The most interesting are those made in the two Eocene lake-basins between the Rocky Mountains, and the Wahsatch Range. These basins were explored by Professor Marsh in 1870, and their Eocene age then

first determined. His explorations in this region have secured to science over 150 species of new vertebrates, most of them widely different from any hitherto known. The most remarkable of these are the gigantic mammals of the new order *Dinocerata*, the type genus of which is *Dinoceras*. These animals nearly equalled the Elephant in size, but the limbs were shorter. The skull was armed with two or more pairs of horn-cores, and with enormous canine tusks, similar to those of the walrus. The brain was proportionally smaller than in any other land mammal. Three genera and several species are known. Remains of more than 100 distinct individuals were obtained, and are now in the Yale Museum. The *Tillodontia* are another new order of mammals discovered in the same Eocene deposits. They possess many remarkable characters, which indicate affinities with the Carnivores, Rodents, and Ungulates. There are two well marked families, the *Tillotheridæ*, from the typical genus *Tillotherium*, which has Rodent-like incisors; and the *Stylinodontidæ*, in which all the teeth grew from persistent pulps. The largest of these peculiar animals was about the size of a Tapir. One of the most interesting discoveries made by Professor Marsh in the Eocene of Wyoming was the remains of Quadrumana, the first found in the strata of America. These early Primates appear to be related both to the Lemurs of the old world, and to some of the South American Monkeys. Two families are known, the *Lemuravidæ*, from *Lemuravus*, the principal genus, which has 44 teeth, and the *Limnotheridæ*, which have not more than 40. The latter group is rich in genera and species. Among the other Eocene Mammals discovered were Marsupials and Bats, not before known in a fossil state in this country. One of the most important Eocene Mammals found was a small ungulate, which is the oldest known ancestor of the horse. It was about as large as a fox, and had four toes before and three behind. The genus was named *Orohippus*, and several species were discovered. These remains, in connection with others from the later Tertiary, enabled Professor Marsh to trace the line of descent which has apparently produced the modern horse. In addition to the Eocene Mammals, many species of Birds, Serpents, Lizards, and other vertebrates were collected.

The discoveries made by the same expeditions in the Miocene and Pliocene lake-basins of the Rocky Mountains and Pacific coast were likewise very numerous, and many new forms of animal life were brought to light. One group of mammals found in the early Miocene of Oregon is allied to the modern *Rhinoceros*, but differs in having a transverse pair of horn-cores on the nasal bones. The genus was called *Diceratherium*, and one of its species is the oldest known member of the Rhinoceros family, if not its progenitor. The most remarkable mammals found in the Miocene were the huge *Brontotheridæ*, which are apparently allied both to the above group and to the Eocene *Dinocerata*. They equalled the latter in size, and had also an elevated pair of horn-cores on the maxillary bones. One genus of this family was previously known

by imperfect specimens. Besides *Brontotherium*, several other new genera of this group were found, represented by portions of over 200 individuals. With these remains was discovered a genus of small equines, *Mesohippus*, about as large as a sheep, and having three toes on each foot, with an additional "splint" bone on those in front, thus forming an interesting Miocene link in the genealogy of the horse, completed by the Pliocene genera. Over 30 species of fossil horses were collected in these formations. Among the interesting animals obtained in the Pliocene deposits were two species of large Edentates, the first Tertiary representatives of this order from America. They belong to a new genus, *Morotherium*. There were also found large numbers of Rhinoceroses, Camels, Suillines, and other mammals, as well as many Birds, Reptiles, and Fishes.

A study of the large series of extinct animals thus collected, and now in the Yale Museum, promises to throw much light on the development of life on this continent, and Professor Marsh has already drawn from them some important principles. One of these relates to the size and growth of the brain in Mammals, from the beginning of the Tertiary to the present time. The conclusions reached may be briefly stated as follows: *first*, All Tertiary mammals had small brains; *second*, there was a gradual increase in the size of the brain during this period; *third*, this increase was mainly confined to the cerebral hemispheres, or higher portion of the brain; *fourth*, in some groups, the convolutions of the brain have gradually become more complicated; *fifth*, in some, the cerebellum and olfactory lobes have even diminished in size. There is some evidence that the same general law of brain-growth holds good for Birds and Reptiles from the Cretaceous to the present time.

Some additional conclusions in regard to American Tertiary Mammals, so far as now known, are as follows: *First*, all the *Ungulata* from the Eocene and Miocene had upper and lower incisors; *second*, all Eocene and Miocene mammals had separate scaphoid and lunar bones; *third*, all mammals from these formations had separate metapodial bones.

In conclusion, Professor Marsh stated that his work in the field was now essentially completed, and that all the fossil remains collected, and in part described, were now in the Yale College Museum. In future, he should devote himself to their study and full description; and hoped at no distant day to make public the complete results.

2. ***Report upon Geographical and Geological Explorations and Surveys west of the*** *100th* ***Meridian***, in charge of Lieut. G. M. WHEELER, Corps of Engineers, U. S. Army. Published by authority of the Secretary of War.—The reports of the work done, up to the close of 1873, make six volumes: I. The Geographical Report; II. A Report on the Astronomy and Meteorology; III. On the Geology and Mineralogy; IV. On the Paleontology; V. On the Zoology; and VI. On the Botany. Besides these, there

are to be two atlases, one topographical and one geological. Volume III, and Part I of volume IV have recently been published.

Vol. III. *Geology*, 682 pp. 4to, with maps, sketches and sections. The geological reports, on portions of California, Nevada, Utah, Colorado, New Mexico and Arizona, making up this volume, are a record of good work and of valuable results. Two of the reports are by G. K. Gilbert, and one each by A. R. Marvine, E. E. Howell, J. J. Stevenson and Oscar Loew. Part of the observations and conclusions of Mr. Gilbert are brought out in an article by him, in this Journal, commenced on page 16 of this volume. They cover the subjects of orology, erosion, glacial phenomena, volcanic rocks, and the stratified rocks. All the reports, and especially Mr. Gilbert's, throw much light on the characters and dynamics of displaced and folded rocks,—a subject which the prevailing absence of soil and forest makes easy of investigation. The volume is illustrated by several fine plates of scenery along the valleys illustrating erosion, and one a case of "rain-sculpture" exemplifying admirably the origin of mountain forms.

Mr. Loew's report discusses the agricultural resources and soil of the regions examined in Colorado, New Mexico, and Arizona, gives analyses and descriptions of mineral waters and minerals, and describes the eruptive rocks.

Vol. IV. *Paleontology*, Part I. Report on the Invertebrate Fossils collected in portions of Nevada, Utah, Colorado, New Mexico and Arizona, by the expeditions of 1871-1874, by C. A White, M.D., 220 pp. 4to, 1876.—After some general observations on the collections and the periods they represent, Professor White takes up the description of the fossils in the order of the formations, and illustrates the large number of species with twenty-one well-filled quarto plates. The fossils belong to the Primordial, Canadian and Trenton periods of the Lower Silurian; a few species to the Devonian; nearly half of all to the Carboniferous age, some of them Subcarboniferous, but the larger part of the Coal period; a few (eight) to the Jurassic period; many to the Cretaceous, and fifteen to the Tertiary. The Primordial animal fossils enumerated and described are *Acrotreta subsidua* White, *Trematis pannulus* White, *Hyolithes primordialis* Hall (?), *Agnostus intestrictus* White, *Conocoryphe Kingii* Meek, *Asaphiscus Wheeleri* Meek, *Olenellus Gilberti* Meek, *O. Howelli* Meek.—The beds of the Canadian period (Quebec Group) afforded him twelve species, among which are the Graptolite, *Phyllograptus Loringi* White, and the trilobites, *Megalaspis belemnurus* White, and *Dicellocephalus? flagricaudus* White. Four species of Graptolites are mentioned from the Trenton beds, *G. pristis?* and *G. quadrimucronatus?* of Hall, *G. ramulus* White, and *G. hypniformis* White. The Primordial fossils are from Antelope Spring, House Range, in Utah, from Pioche in Nevada, and from Ophir City, Oquirrh Range, in Utah; the Quebec fossils are from Fish Spring in House Range, and from Schellbourne and Queen Spring Hill in Schell

Creek Range in Nevada. Of Subcarboniferous species, five from a locality below Ophir City, are identical with Mississippi Valley species, of the Kinderhook group, *Strophomena rhomboidalis*, *Spirifer peculiaris*, *Sp. centronatus*, *Sp. extenuatus*, and *Terebratula Burlingtonensis*. Prof. White remarks on the similarity of the conditions in the coal-measure area over the Rocky Mountain region to those of the Subcarboniferous, and thus accounts for the close relations of the two in fossils. Of the coal-measure plants in the collection there is only a single specimen each of *Sigillaria* and *Neuropteris*, land plants being the rarest of fossils.

The descriptions of species throughout the work are well drawn up, and many points of general interest are brought out.

3. *Historical Sketch of Geological Explorations in Pennsylvania and other States;* by J. P. LESLEY, with an appendix, 200 pp. and xxvi pp. 8vo. Harrisburg, 1876.—Prof. Lesley's review of early American geological papers and explorations, constituting his chapter I, will be read with great interest. It is written with spirit and illustrates well the progress of geological ideas in the country, though laughing sometimes too heartily and inconsiderately we think over old errors incident to that progress.

Chapter II treats of the work of the short-lived "Geological Society of Pennsylvania," and "what it did to bring about the first geological survey of the State."

Chapter III gives a detailed history, geological and personal, of the first geological survey of Pennsylvania, and has special value since some of the most important principles now adopted in North American geology were then developed. In some cases, however, the views commended by the author are not those which most others would equally commend. For instance, this: "that existing mountains are the remains of a continent once standing at some easily determined higher level than the present continent;" and that this idea "has sent out of existence the old-time notions of mountains of elevation." The principle cited looks strange along side of the fact—one of many—that a large portion of the Rocky Mountain region was under salt water in the Cretaceous, and has since, some how, got up six to ten thousand feet above the sea-level. It involves an exaggerated use of one good idea at the expense of another of greater importance. But notwithstanding some such peculiarities, and the too great freedom of personal remark occasionally indulged in, American science is indebted to the author for the history.

4. *Second Annual Report of the Geological and Agricultural Survey of Texas;* by S. B. BUCKLEY, State Geologist. 96 pp. 8vo. Houston, Texas, 1876.—This report makes brief mention of some localities of the different rock-formations of the State, and treats more at length of the mineral and agricultural products. It is stated that in the valley of the Rio Grande, from six miles below Fort Quitman northward to El Paso, there are two and sometimes three terraces. The two upper consist of sand and gravel. The gravel is often filled with large water-worn quartz pebbles, and in

some places have a thickness of 100 feet or more; and for a large part of the way it is fifteen or twenty miles from the river. Veins of argentiferous galena are reported in the Organ Mountains, in El Paso County, and in the Chinati Mountain, Presidio County, (affording 16 to 76 dollars of silver to the ton); and five miles northeast of Mason in Mason County.

A mass of meteoric iron is contained in the State collections at Austin, weighing 315 pounds, which is said to have been found on the head waters of the Red River, northward of Young County.

5. *Primordial of Scandinavia.*—According to G. Linnarssen (Geol. Mag., April, 1876, p. 146, in a reply to a paper by Mr. H. Hicks), the oldest fossiliferous rocks of Scandinavia consist, in ascending order, of (1) the Eophyton sandstone; (2) the Fucoid standstone; and (3) the Paradoxides schists; and the last corresponds to the Harleck and Menevian groups of the British Lower Cambrian. The Paradoxides schists contain the Trilobite genera *Paradoxides* (*Anopolenus*, *Plutonia*), *Conocoryphe* (*Erinnys*), *Microdiscus*, *Arionellus*, *Agnostus*, and also *Leperditia*, *Hyolithus*, *Lingulella*, *Obolella*, *Orthis*, *Protospongia*, etc. The beds below the Paradoxides schists contain no trilobites. The Fucoid sandstone has afforded two species of *Lingulidæ*, and the Eophyton sandstone a number of species of *Brachiopods*, *Pteropods*, *Spongiæ*, besides the doubtful *Cruziana*, *Harlania* (*Arthrophycus*), *Eophyton*, etc. Forms like those of *Cruziana* and *Eophyton* have been found also at other horizons higher in the Silurian, and a Harlania much like the Primordial in the Rhætic beds of Scania. One of the Brachiopods of the lower beds of the Eophyton sandstone is the *Lingula* or *Obolus monilifer*, but it probably pertains to a new genus; and two other fossils are *Hyolithus lævigatus* and *Astylospongia radiata.* The thickness of the sandstone under the Paradoxides schists in Scandinavia is but a fifteenth of that of the corresponding beds in the English Cambrian; but this is no evidence that the former are younger than the latter.

The "Primordial zone" or stage C, of Bohemia is younger than the oldest fossiliferous strata of Scandinavia, and corresponds most nearly with the middle of the Paradoxides schists. That any identical species occur in both is not certain; but there are several that are closely related, as *Paradoxus Tessini* and *P. spinosus*, *Ellipsocephalus Hoffi* and *Agnostus rex.*

6. *Glacial flood.*—In a paper "on the Drift-deposits of the Northwest," in the Popular Science Monthly for July, 1873, Prof. N. H. Winchell presents the view that the terraces along the rivers and about the lakes of the Northwest [the northern part of the Continental Interior] are due solely to floods along the rivers and the lakes consequent on the melting of the great glacier. The investigations which I have made since the publication of his paper, and which are the subject of my recent memoir on Southern New England, have satisfied me that in this he is essentially right. Prof. Winchell argues, thence, against the opinion that the Champlain period was one of more or less depression of the

land over the higher latitudes of the Continent. But this conclusion does not necessarily follow, as is evinced by the facts over New England. When he says "the four-hundred-foot beach near Montreal may have had the same origin as the so-called beaches that rise several hundred feet higher in the State of Ohio," his language is ambiguous; but interpreting it by the context it is wrong, if we may trust Logan, Dawson, and others, who have studied those high St. Lawrence "beaches;" for these geologists describe them as true sea beaches and under-water marine deposits, containing *marine* shells, and some of the beds, as I know from examination, are full of such shells; and this they could not be if made by fresh water floods. The same is true of the elevated beaches on Lake Champlain, and of others on the Coast of Maine. Wherever such beaches occur they prove a depression of the land during the era of their formation; and their wide distribution leads to the natural inference that all northern New England participated in the subsidence. Such Eastern facts do not, however, *prove* that the Continental Interior, farther west, participated in the subsidence; and yet this may have been a fact. Whether so or not facts that will demonstrate the truth are difficult to find over the interior of a wide continent, and hence a uniform opinion among geologists may never be reached. J. D. D.

7. *On the Ice Age in Great Britain*; by RALPH RICHARDSON.—In this paper (Proc. Edinburgh Geol. Soc., 1876) the author gives the facts with regard to the shallow depths of ocean between Great Britain and Iceland and Greenland on one side and over the German Ocean on the other, and presents reasons for believing that there was dry land over the region in the Glacial era; that the Glaciers of Great Britain came over this emerged land from the north and west; and that the cold of the Glacial era was due in part at least to the closing thus of the Arctic, and excluding thereby the Gulf Stream. The facts appear to sustain the conclusions. The depth between Britain and Iceland mostly does not exceed 100 fathoms, and no where exceeds 1,000; and one tract of sea extending in a straight line from the eastern coast of Greenland *via* Iceland and Faroe to Scotland does not exceed 500 fathoms. The depth of the sea in the English Channel is only about 20 fathoms, and the average depth of the North Sea or German Ocean is not over 40 fathoms or 240 feet. The depth between Britain and Greenland is small compared with the average depth of the Atlantic. The author closes with the conclusion, that one of the oscillations of level, such as have often occurred over the earth's surface, had the effect to "unite Britain and Northern Europe with Greenland and the Arctic regions;" "to give the polar ice-fields access to Europe;" "to divert the course of the Gulf Steam and free Northwestern Europe from its influence; and, in conjunction probably with some diminution in the influence of the sun, to produce a Glacial epoch."

8. *Geology of Spitzbergen.*—The following facts and views on the Geology of Spitzbergen are taken from articles by Prof. Nord-

enskiöld in the January and February numbers of the Geological Magazine, edited by H. Woodward, F.R.S.—The glacial scratches in the fiords opening into Bell Sound appear to indicate that the west coast of Spitzbergen extended at least to the series of islands and rocks by which the land is now environed; and that "during the Glacial period that coast was the west coast, not merely of an island, but of a considerable Arctic continent, which toward the south was connected with Scandinavia and toward the east with Continental Siberia." These words are italicized.

No strata containing Silurian fossils have yet been found, although it is probable that the Scandinavian Silurian formation is represented by dolomitic beds, slates, and quartzyte in Mt. Hecca Hook on Treurenberg Bay. The last-mentioned quartzyte in Lomme Bay is overlaid by slates, limestone, sandstone, and conglomerates, which have afforded remains of fishes and some other undetermined fossils and are probably of the age of Upper Devonian or Lowest Carboniferous.

The rocks of the Carboniferous age include a lower and an upper Subcarboniferous limestone, and the true Carboniferous formation.

The Lower Subcarboniferous beds (called "Ursa Stage" by Heer), are best developed on Bear Island, and include therein sandstone with some slate and coal; they occur also on Ice and Bell Sounds. The eighteen Bear Island species that have been determined are *Calamites radiatus* Brgn., *Cardiopteris frondosa* Gœpp., *C. polymorpha* Gœpp., *Palæopteris Rœmeriana* Gœpp., *Sphenopteris Schimperi* Gœpp., *Lepidodendron Veltheimianum* St., *L. commutatum* Sch., *L. Carnehgyianum* H., *L. Wijkianum* H., *Lepidophyllum Rœmeri* H., *Knorria imbricata* St., *Kn. acicularis* Gœpp., *Cyclostigma Kiltorkense* Haught., *C. minutum* Haught., *Halonia tuberculosa* Brgn.? *Stigmaria ficoides* St., *Cadiocarpum punctatum* Gœpp. and Berg., *C. ursinum* H.

The Upper Subcarboniferous formation consists, beginning below, of (1) dolomite; (2) red and white sandstone; (3) Cyathophyllum limestone, containing fossil *corals*, *Brachiopods*, *Crinoidal remains*, a *Euomphalus;* (4) Spirifer limestone and gypsum, affording numerous remains of *Spirifer* and some of *Productus;* (5) Productus limestone and flint. The formation has afforded 4 species of polyp corals, 2 of Crinoids, 7 of Bryozoans, 34 of Brachiopods, 11 of Lamellibranchs, 2 of Gasteropods, 2 of Crustaceans, and 1 of Spongia. They include some species that have been supposed to be exclusively Permian, as *Camaraphoria Humbletonensis* Howse, *Productus Cancrini* Vern., *Productus Leplayi* Vern., *P. horridus* Sow., *Strophalosia lamellosa* Gein. *P. horridus* is very abundant and occurs of great size (86 mm. by 67), nearly twice as large as is known from the Permian. The beds contain also the Silurian species *Rhynchonella pleurodon* Sow., but no *Orthis;* the Russian Subcarboniferous species *Spirifer incrassatus*, *Sp. bisulcatus* var. *Sarana*, *Terebratula fusiformis*, *Productus Humboldti*, *Chonetes variolaris;* and the Carbonifer-

ous species *Euomphalus cattilus*, *Monticulipora tumida*, *Chætetes radians*, *Cyathophyllum ibicinum*, *Syringoporæ*, etc.

The *Coal-Measures* have been distinguished on Spitzbergen only "in Robert's Valley, on the eastern side of the great bottom glacier in Recherche Bay," where the thickness is 1,000 to 2,000 feet. There is some black shale but no true coal. Species of *Sphenopteris*, *Cordaites* (*C. boracifolia* and *C. primordialis*), *Lepidodendron* are common, and some occur of *Stigmaria*, *Sphenophyllum*, *Asterophyllites*, but none of *Pecopteris* and *Neuropteris*. The same strata probably extend over Cape Ahlstrand to Van Keulen's Bay, and may occur at various other places.

The *Triassic formation* is met with in Ice Sound. The beds are principally black clay-slate with some beds of limestone and coprolitic layers. The beds have afforded remains of *Ichthyosaurus polaris* Hulke (of the size of *I. Platiodon*), *I. Nordenskiöldii* Hulke, *Acrodus Spitzbergensis* Hulke, and other vertebrates yet undetermined, besides (according to Dr. Lindström) *Ceratites Malmgrenii* Lindstr., *Halobia Lommelii* Wissm., *H. Zitteli* Linds., species of *Posidonia*, *Monotis*, etc. Some of the coprolites contain 23 per cent of phosphoric acid.

9. *The Coal Eras of India, and a Permian or Triassic Glacial period.*—Mr. H. T. Blanford, in an able paper in the Quarterly Journal of the Geological Society of London for 1875, p. 519, discusses at length the age of the coal-bearing strata of India and the evidences of a Glacial era in underlying conglomerate beds.

(1). *Coal beds and Eras.*—He arrives at the conclusion, with regard to the coal-beds, that they range from the Lower Permian to the latest Jurassic.

The beds of the Dómúdá valley, the Rájmahál hills and numerous small basins west of the Gangetic delta consist, in ascending order, of (1), The Talchir group, 800 feet; (2), the Dámúdá series (including the Barákar group (2,000 feet), the Ironstone shales (1400) and the Ránigạnj group (5,000), 8,400 feet; (3), the Panchét group, 1,500 feet; and (4), Coarse sandstones and conglomerates, 500 feet. The flora of the Ránigaṇj group, includes *Glossopteris Browniana*, *Phyllotheca Indica*, *Vertebraria Indica*, besides other species of these genera, and some also of *Pecopteris*, *Cyclopteris*, *Sphenophyllum*, *Calamites*, and *Schizoneura*. The overlying Panchét group contains species of *Sphenopteris*, *Tæniopteris*, *Neuropteris* (?), *Schizoneura*, *Preissleria*; also two *Labryinthodonts* (Huxley), a *Dicynodont*, a *Thecodont*, (*Ankistrodon Indicus* Huxley), an *Estheria*, etc.

In the Rájmahál hills, beds, supposed to be equivalents of the Ránigaṇj group, are overlaid unconformably by the Rájmahál group, which contain, besides species of the last-mentioned genera, others of *Walchia*, *Voltzia* and an abundance of *Cycads*; all are specifically distinct from those in the older groups. Besides these species, the beds contain woods of *Dadoxylon*, *Palæoxylon*, *Taxoxylon*, and of *Angiosperms* of three or four varieties, but no ani-

mal remains. In the Nagpore country and Godavery valley, the Talchir and Damuda series are recognized, the latter with *Glossopteris Browniana*, etc., and, above the latter, the Panchét group, containing remains of *Ceratodus* and *Hyperodapedon*, both Triassic genera in Europe, and the former living still in Australia. Still higher, there are beds containing Cycads. In Cutch, there are Cycads in beds—probably equivalents of the last—that are either upper Jurassic or lowest Cretaceous.

Mr. Blanford speaks of the above correspondence—which has long been recognized—between the plants of the Damuda series and those of the coal measures in eastern Australia, 5,500 miles from the Indian localities, and in the Karoo formation in Natal,—South Africa. From the facts, he makes the beds in these distant regions alike in age, and Permian. The Beaufort beds, an upper member of the Karoo series, contain remains of *Dicynodon*, *Microlophis Stowii* Huxley, *Galesaurus* and *Cynochampsa*, along with *Glossopteris Browniana*, another Glossopteris, and a Phyllotheca near *P. Indica*; and they are made by the author equivalents of the Panchét group.

(2.) *Glacial era.*—At the base of the Talchir group, (as first announced in vol. i of the Q. J. G. Soc.) there is a conglomerate consisting of blocks of all sizes, up to *forty-two feet in circumference*, imbedded in a firm silt. The bowlders, as first shown by Dr. Oldham and Mr. Feddan, in 1872, are in part scratched and polished, part like the polish of a lapidary; and the underlying Vindhyan limestone is also scratched in long parallel lines. In the South African Karoo region, there is a similar bowlder bed beneath the coal measures, in which bowlders of granite, gneiss, etc., of all diameters up to *five* or *six feet* are imbedded in a grayish blue argillaceous base, which is in some places ripple-marked. These conglomerate beds have the great thickness of 800, and in some places, 1,200 feet. Below are beds containing *Lepidodendra*, etc., which have been referred to the Carboniferous. No similar bowlder bed has been observed in Australia. Mr. Blanford regards the bowlder beds as having originated under glacial conditions, and thinks it probable that those of India and South Africa point to one and the same Glacial era. Making the lower coal-beds Permian, the Glacial era is of the early Permian; contemporaneous with that indicated by the breccias of the British Lower Permian.

Mr. Tate, who has described, with Prof. T. Rupert Jones, the Karoo formation of South Africa, makes its age, as Mr. Blanford states, Triassic; and others have taken the same view of the coal beds (containing *Glossopteris*, etc.) of India and Australia. This view has to encounter the facts, stated by Rev. W. B. Clarke, that a coal miner's shaft sunk at Harper's Hill, New South Wales, passed through nearly horizontal beds containing *Spirifer*, *Fenestella*, *Conularia*, *Orthoceras*, etc., before reaching the conformable coal beds of the region full of *Glossopteris*, *Phyllotheca*, etc.; and also others, from Bowen River, Queensland, described by Mr. Dain-

tree, where the *Glossopteris* beds are *overlaid* by *Productus* and *Spirifer*-beds.

The paper is accompanied by a map showing the distribution of the plant beds in Eastern India, between the Ganges and the southwestern side of the Godavery River; and of others farther south, near Madras and Trichonopoly, and in the district of Cutch, where only the later beds have been observed.

10. *Graptolites.*—An article by Messrs. John Hopkinson and C. Lapworth, describing forty-five species of Graptolites from the Arenig and Llandeilo rocks of St. David's, illustrated by numerous figures on five plates, is contained in the Quarterly Journal of the Geological Society for November last. It is of special interest to the American geologist because of the many American forms which it reports from some of the British localities. In the lowest beds of the Arenig rocks, in Whitesand Bay, the species are all new; but on Ramsay Island, of nearly the same horizon, out of 16 species, 6 were first described by Hall from the Quebec group, viz: *Dendrograptus diffusus*, *D. divergens*, *D. flexuosus*, *Didymograptus extensus* and *D. pennatulus*, and *Trigonograptus ensiformis*. The beds also contain other species of the first two genera, and species also of *Phyllograptus*, *Ptilograptus*, *Callograptus* and *Dictyograptus* (*Dictyonema* Hall). The Middle Arenig beds of Whitesand Bay contain Hall's species, *Didymograptus patulus*, *Tetragraptus* 4-*brachiatus*, *Dendrograptus flexuosus*, *Callograptus elegans*, *C. Salteri*, and *Dictyograptus* (Dictyonema) *irregularis*; and the Upper Arenig of Ramsay Island, Hall's species, *Didymograptus bifidus*, *D. indentatus*, and *D. patulus*. No American species are among the eleven obtained from the Llandeilo formation: these eleven are of the genera *Didymograptus*, *Dicallograptus*, *Climacograptus*, *Diplograptus*, *Ptilograptus*, *Dendrograptus* and *Dictyograptus*.

11. *Region of eruptive rocks of the District of Schemnitz, Hungary.*—Mr. J. W. Judd, in a paper read before the Geological Society in April last, describes this Hungarian region of eruptive rocks. The rocks are andesites of the earlier upper Miocene age, rhyolytes of the later, and basalts of the Pliocene; also highly metamorphic rocks, including quartzytes, crystalline limestones, various schists, gneiss and aptyte, which are Triassic in age; and so-called syenyte, granite and greenstone. As held by Von Pettko, Richthofen, and others, the greenstones are Tertiary, they naming them greenstone-trachyte and propylyte; and, according to Judd, the granite and syenyte are only coarser forms of trachyte of the same age. The author also observes that there is complete proof that the mineral veins containing gold, silver and other metals, in Schemnitz, were formed "within the most recent geological periods, in some cases indeed, at a later date than the Pliocene."—*Nature*, No. 34.

12. *Volcanic phenomena of the Alps.*—Recent numbers of Woodward's "Geological Magazine" contain a valuable series of papers on volcanoes and volcanic phenomena, of British and European

regions, by Mr. Judd. The article in the number for May treats of the igneous ejections preceding the elevation of the Alps, which commenced in the Permian and continued through the Triassic. The best exhibitions of the erupted rocks are seen near the Lake of Lugano, on the borders of Switzerland and Italy, in the Southern Tyrol, and in the country about Raibl in Carinthia; and the author holds that they indicate that the same rocks occur beneath the Jurassic or other overlying beds throughout the Alpine region. The oldest (Permian)—the quartz-porphyry of Botzen, or a granite-like variety containing 66 to 76 p. c. of silica—covers an area of more than 1,000 square miles and constitutes mountain masses over 9,000 feet high. It is largely covered by Triassic beds of great thickness. Eruptions of the Triassic period occur in the Southern Tyrol; the rocks have the composition of melaphyre, diabase and doleryte, but are often granitic in texture, and are called monzonyte; and besides, there are tufas and volcanic ashes. Monzoni and Predazzo are noted localities, and especially because of the many minerals produced in the adjoining rocks by the erupted monzonite; among them, epidote, garnet, spinel, vesuvianite, gehlenite, mica, biotite, wollastonite, anorthite, labradorite, orthoclase, scapolite, monticellite, axinite, zircon, sphene, besides serpentine, thomsonite, chabazite, prehnite and others—a series closely related to that from the ejected masses on Somma.

13. *Reliquiæ Aquitanicæ.* Part xvii, Nov. 1875.—This number concludes the very valuable work of Lartet and Christy on the "Archæology and Palæontology of Périgord, and the adjoining Provinces of Southern France," issued under the editorial supervision of Prof. T. Rupert Jones, and published by Williams & Norgate, London. The number of quarto plates in the whole work is eighty-three, and, besides these there are many wood-cut illustrations. This last number adds to the information on the human remains of Laugerie Basse, and concludes with notes on the *Caribou* (Reindeer) of Newfoundland, and comparisons of Reindeer remains from the caverns, giving a copy of a sketch of a Reindeer on a piece of Reindeer antler from a cave in the Canton of Schaffhausen; on the *Ovibos moschatus*, a northern species at the present time, whose remains have been met with not only in the Quaternary of Great Britain, but also in the "Diluvium" of the Oise near Chauny, and at Precy, and in that of the Saal in the Gorge d'Enfer (Dordogne). The last is at present the most southern locality known; and with the remains occur those of the Cave Bear, Cave Lion, Wolf, Aurochs and Reindeer. Next follow important "Supplemental notes," containing Addenda and Corrigenda for the work.

14. *On Dalmanites dentata*; by Dr. S. T. Barrett.—Mr. J. M. Dolph of this place has recently found a nearly entire specimen of *Dalmanites dentata*, which enables me to add the following to my description of that species (p. 200 of the last volume of this Journal), and make some corrections. The thoracic segments are as described, except that all do not terminate laterally in slender

terete spines; the eight posterior segments do. Of the three anterior the first from the shield does not and the second does end obtusely, while the third has a spine about half the length of the fourth. These spines are directed outward and backward nearly at right angles to the rest of the segment, curving slightly upward near the end.

The entire specimen has an oblong-subelliptic general outline; length about equal to twice the width.

PORT JERVIS, N. Y., May.

15. *Note by Dr. Hayden, on the ore-bearing rocks of Colorado.*—In the annual report of the U. S. Geological and Geographical Survey of the Territories for 1874, on page 4, the statement is made that the "granites, schists, etc., are of probable Archæan Age, in which alone the precious metals and minerals of Colorado have been found." This statement was copied from the manuscript of Mr. Marvine, and was intended to apply only to his district, which embraced the Middle Park and the mountains about Georgetown and Central City. In the report of 1873 it was stated that ores of silver and gold occur in the Park Range, west of South Park, in limestones and quarzites of Silurian? Age, and in volcanic rocks, probably trachytic. In the Elk Mountains, galena and other silver ores occur in metamorphosed shales and quartzites of Cretaceous Age.

16. *Geology of Sumatra.*—The Geological Magazine for October and November, 1875, contains papers by R. D. M. Verbeek on the geology of Sumatra. An article on four fossil fishes, collected by Mr. Verbeek from the Lower Tertiary (or Upper Cretaceous) beds, has been published by Dr. Geinitz and Dr. V. d. Marck, in the Mitth. Königl. Min. Museum in Dresden. The article is illustrated by two plates.

17. *Report on the Geology of Wisconsin.*—This Report, prepared while the survey was under the charge of the late Dr. Lapham, is soon to be published, the Legislature of the State having appropriated $20,000 for the purpose.

18. *Geology for Students and General Readers.* Part I. *Physical Geology.* By A. H. GREEN, M.A., F.G.S. 522 pp. 12mo. London, 1876. (Daldy, Isbistin & Co.)—This volume gives a good review of Lithological and Dynamical Geology.

19. *Bulletin of the U. S. National Museum.* Department of the Interior. Published under the direction of the Smithsonian Institution. Nos. 1 and 2. 104 and 52 pp., 8vo.—No. 1. Contains three papers by E. D. COPE: (1) Check-list of N. A. Batrachia and Reptilia; (2) Check-list of the species of Batrachia and Reptilia of the Nearctic or N. American realm; (3) Geographical distribution of the Vertebrata of the Nearctic realm with especial reference to the Batrachia and Reptilia; (4) Bibliography. Mr. Cope's extensive knowledge of the species here considered and of their habits and distribution renders these chapters of great value to North American Science.

No. 2. Contributions to the Natural History of Kerguelen Is-

land made in connection with the American Transit-of-Venus Expedition, 1874–75; by J. H. KIDDER, M. D., U. S. N. I. Ornithology, edited by Dr. ELLIOT COUES, U. S. A. The collection made by Dr. Kidder contains 11 Procellaridæ, 4 Spheniscidæ, 3 Laridæ, and 1 each of the families Phalacrocoracidæ, Anatidæ, and Chionidæ. The Introduction states that the highest peak of the island, Mount Ross, is 5,000 feet in altitude and always snow-covered. Near the sea, in December, the snow-line was found on Mt. Crozier at about 2,000 feet above the sea-level. Only 27 days out of four months were without snow or rain, and a still smaller number of nights; the mean temperature for the year is near the freezing-point, varying but little from this at any time; and the island is notorious for the violence of its gales. Consequently there are no trees or shrubs, and no plant taller than a Kerguelen cabbage; and the few phænogamous plants that survive are such only as can thrive exposed to these hardships. As a natural consequence, although the island is 90 miles by 50 in area, there are no land-birds or mammals living on the island, and but a single shore-bird, *Chionis minor.*

20. *Chemisch-genetische Beobachtungen über Dolomit,* (mit besonderer Berücksichtigung der Dolomit-Vorkomnisse Südost-Tirols), von Dr. C. DŒLTER und Dr. R. HŒRNES.—This memoir contains a full review of the literature of the subject, with a discussion of the various theories which have been proposed to explain the existence of the great strata of dolomite. The results of an extended chemical examination of the dolomites of the Tyrol by Dr. Dœlter are given, embracing a considerable number of analyses. The authors reach the following conclusions, confirming in part the results of some earlier authors.

(1.) A large number of extensive strata of limestone, weakly dolomitic, have been deposited immediately through the instrumentality of organic life in the ocean.

(2.) Some minor occurrences of normal dolomite are due to subsequent metamorphosis, through the introduction of carbonate of magnesia.

(3.) The larger part of the dolomites, whether more or less rich in magnesia, have been formed from the lime secretions of sea-animals through the action of the magnesia salts contained in the sea-water (especially chloride of magnesium). Subsequent local differences have been brought about through circulating waters, dissolving out and concentrating the magnesia at different points.

E. S. D.

21. *On the Pittsburg Meteoric Iron;* by Dr. F. A. GENTH.—A chemical examination of the Pittsburg meteorite yielded the following results: Its specific gravity, which Shepard gave as 7,380 was found to be 7,741, the average of three closely corresponding determinations by Dr. Kœnig, Dr. Headden, and myself. After polishing and etching with dilute nitric acid, it presents Widmannstättian figures, which are produced by inclosed schreibersite. In the section which has been made, it happens that most

of the exceedingly minute schreibersite crystals are cut across and are seen as small dots on a frosted surface; some appear as minute needles, arranged in parallel lines, like the trees in an orchard. A few elongated patches of a whiter iron-nickel alloy are also visible.

The analysis of a somewhat oxydized piece, gave the following composition:

Iron	92·809
Copper	0·034
Cobalt	0·395
Nickel	4·665
Manganese	0·141
Sulphur	0·037
Phosphorus	0·251
	98·332

0·251 per cent of phosphorus is equal to about 1·8 per cent of schreibersite.—*From the Report of the Geological Survey of Pennsylvania for* 1875.

III. Botany and Zoology.

1. *Tree-planting, Prizes for Arboriculture.*—Prof. C. S. Sargent, the Director of the Botanic Garden and Arnold Arboretum of Harvard University, published two or three months ago, *A Few Suggestions on Tree-planting*, in the Massachusetts Board of Agriculture's Report for 1875, and an edition was separately issued. The economical importance of re-foresting poor or agriculturally worthless lands in that State, and elsewhere, was strongly stated and judiciously enforced by plans and estimates, and the proper trees for planting on a large scale indicated. Another board, namely the Trustees of the Massachusetts Society for Promoting Agriculture, having some trust-funds at disposal, has now come forward, reprinted Prof. Sargent's pamphlet for gratuitous distribution, adding particular directions for the planting and management of seedling trees, and offering very handsome prizes for special plantations within the State of Massachusetts. This board offers, in the first place, for the best plantation of not less than five acres of larch, or on the cape, &c., of Scotch or Corsican pine, originally of not less than 2700 trees to the acre, on poor, worn-out or otherwise agriculturally worthless land, a prize of $1000. For the next best, a prize of $600; for the third best, $400. Next, for the best plantation of the same extent with American white ash, not less than 5000 trees to the acre, a prize of $600; for the next best, $400. Intending competitors must notify the Secretary of the Society, E. N. Perkins, Jamaica Plain, Boston, as early as Dec. 1, 1876, and plant in the spring of 1877. Special directions, not only for planting and caring for, but also for procuring trees for the purpose, are given in the pamphlet, and a citizen of Boston patriotically offers to look after the importation

of the seedling trees, which in such quantities and for next year's planting would have to be obtained mainly in Europe, at least the pines and larches. The ashes, probably, would have to be raised from seed; and the time, if need be, would doubtless be extended. The prizes to be awarded in the summer of 1877. Mr. Sargent's estimates promise a handsome return for the capital and labor invested in judicious tree-planting for economical purposes; these timely prizes may stimulate enterprise; and the sense of contributing to the adornment as well as to the material resources of the country should also be a motive and a reward. A. G.

2. *Heteromorphism in Epigæa.*—The May-flower, being more largely gathered and brought under our notice than any other wild blossom—at least in the Atlantic States—should be well known in all the details of structure. But it hardly is so. The structure of its stigma was first well described in the 5th edition of my Manual of the Botany of the Northern United States, and the likeness to *Pyrola* suggested. I suppose that this likeness is really one of relationship, but not of a near degree, as most other points of similarity are wanting. From the difference in the stigmas of different flowers, I was disposed to think that the five lobes lengthened and protruded with age, in the manner of *Pyrola;* but this does not prove to be the case. In all cases, however, the apex of the style is as it were hollowed out or extended into a ring, with a 5-crenate border, to the inner face of which the five stigmas are adnate, each before one of the small teeth or lobes, and extending sometimes slightly beyond it, but remaining short and erect, sometimes much beyond and radiately expanded.

In Michaux's Flora is the note "Flores omnes in nonnullis individuis abortivi," and botanists are generally aware that fruit is seldom met with. The flowers have been said to be unisexual (diœcious); but all appear to have well formed ovary and ovules, although some individuals were known to want the stamens. Professor Goodale, knowing a station in Maine in which *Epigæa* year after year sets fruit, kindly procured from thence a large number of fresh specimens; and these I have now examined in regard to stamens and pistil. They show the following heteromorphous condition of things.

(1.) About ten per cent of the specimens have a style considerably longer than the stamens, raising the stigmas a little out of the throat of the corolla, in which the anthers are included: the stigmas are cylindraceous, radiate like the spokes of a wheel, half a line in length, therefore strongly projecting, moist and glutinous, and evidently in good condition for fertilization. The anthers in these flowers are slender, commonly withering without dehiscence, and containing few yet perhaps well-formed pollen-grains. The fruiting specimens gathered at the same station in former years all evidently belong to this form, as the persistent style and long stigmas show. One or two specimens of this form manifest a disposition to convert their anthers into petals; but this is occasionally seen in other forms.

(2.) A smaller number of specimens show the stigmas of the preceding on a shorter style, sometimes so short as to place the radiating stigmas as low as the middle of the tube of the corolla, sometimes bringing it nearly up to the throat. In one instance a short-styled flower was detected in a cluster of flowers otherwise of the character of No. 1. These short-styled blossoms, instead of having more conspicuous or higher anthers than in the long-styled, bear them either at the same proportional height and in the same condition, or bear mere rudiments of anthers, or not rarely none at all, and even the filaments are smaller, abortive, or occasionally altogether wanting. This sometimes happens in No. 1 also.

(3.) The larger number of flowers, perhaps three-fourths of the specimens under examination, have the long style of No. 1, an ovary equally well-formed and ovuliferous, but either rather smaller or not going on to grow; but the stigmas are short, only slightly projecting beyond the lobes of the cup to which they adhere, in all stages erect, and comparatively smooth and dry. Their tips, however, appear somewhat papillose under a strong lens, and grains of pollen placed thereon incline slightly to adhere, yet not so much as upon the surface of the style far below, which gets well covered with pollen from the contiguous anthers. The difference between these stigmas and those of the foregoing forms is striking and constant, no gradations between them having been detected. The anthers abound with pollen, and are dehiscent at or a little before the opening of the corolla.

(4.) A considerable number of such flowers have a shorter style, so that the stigma stands as low as the base of the five longer anthers, in one or two even lower than all the anthers, otherwise all is as in No. 3, of which this seems to be a mere variation. And here also, although not very definitely, there is a tendency to having lower instead of higher anthers in connection with the short style.

The flowers of *Epigæa* may therefore be classified into two kinds, each with two modifications; the two main kinds characterized by the nature and perfection of the stigma, along with more or less abortion of the stamens; their modifications, by the length of the style. The first is leading to dioicism, the second points to dimorphism. I am not aware that either unisexual or dimorphous flowers are otherwise known in the *Ericaceæ*. Dimorphism (as exemplified in Primroses, *Houstonia*, and *Mitchella*) may be regarded as the more perfect arrangement on the score of economy, as it secures cross-fertilization along with fertility of all the flowers. It would seem as if this had been attempted in *Epigæa*, but that the stamens did not respond with the requisite correlation to the long and short styles; and the same may be said of certain flowers in one or two other families. Of dichogamy, the other equally economical method, I find no indication in *Epigæa* blossoms. But they appear to be now falling back upon the remaining, less economical mode of securing the end, namely, by unisexual blossoms.

It would be interesting to know whether the small-stigma

forms of *Epigæa* are ever fruitful, or fully so. It might not be difficult to ascertain the kind of flower in any case which has matured fruit; for the style and stigmas persist until the capsule is well formed in the fruit thus far known.

The æstivation of the corolla is that of the tribe, imbricated, but with a strong tendency to convolute; more commonly there is only one exterior and one interior lobe. A. G.

3. *Essay on the Immigration of the Norwegian Flora during alternating Rainy and Dry Periods*, (with a colored map of Norway); by AXEL BLYTT. Christiania. pp. 87, 8vo. 1876.—This is the substance of two lectures delivered by Dr. Blytt at meetings of the Christiana Natural History Society, in January and in October, 1875. Dr. Blytt's father was the most accomplished botanist of Norway, and the son takes naturally and lovingly to the same pursuits. Following the example set by Dr. Thorel and other Scandinavian naturalists, and which is to us pleasant and convenient, Dr. Blytt publishes this essay in the English language, which he writes correctly and with apparent ease.

There are, so to say, two floras in Norway; one, which may be termed the insular, belongs to the coast or western part of the country, to which the Gulf-stream has given an insular character of climate; the other, the continental or boreal. There are, besides, the generally diffused species, which are indifferent to the variations of climate. The rare continental species prefer a dry and loose substratum; the insular, a solid or moist soil; and there are remarkable leaps in the extension of both the continental and insular species. To explain these leaps is to bring in the question of the migration of plants. "Do plants migrate all at once across large tracts, or do they extend themselves little by little and by short distances at a time?" Although drifting ice, bringing seeds and plants lodged in earth, is a known means of transport, yet "everything indicates that conveyance to small distances is the rule." The case of the Norwegian flora "becomes easily intelligible if we assume that our climate since the ice-period has undergone secular alterations; that it has been at certain times more insular, and at others more continental; when a dry period is succeeded by a moist period the continental species must become rarer; when a moist period is followed by a dry time the plants which love moisture will be scarcer. Thus the great leaps in the distribution of species seem to point to a more continuous extension in ancient times." The study of peat-bogs resting on the site of extinct forests, and these of different ages and character, furnishes evidence of these perturbations of climate, extending through long and remote periods. "During such alternating periods," wholly prehistoric, "the country seems therefore to have received its present vegetation. We see it first covered with inland ice, which projected out into the sea and dispersed Scandinavian migratory blocks over the plains of Central Europe. When the ice, during a drier period, retired from the shore, a flora immigrated resembling that which now adorns the

wastes of Spitzbergen, North Greenland, and Melville Island,—small, hardy, and tuft-forming plants, which often display an unexpected splendor of flowers with the purest and deepest colors. Then came the gray osiers, juniper and birch, cherry-ash and rowan, with a host of new immigrants. The moisture increased, peat began to grow, and the arctic flora to recede. But the climate became warmer; the ice melted more and more; elm and hazel, lime, ash and maple, and other tender foliferous trees came, with a number of species that grow in their company. At that time the climate was dry. But when the land rose further a new revolution came about. A great rainy period buried the foliferous forests in peat; then came fox-glove (*Digitalis*), holly (*Ilex*), and the other species which we now find, especially in the rainy regions of the west coast. A new dry period followed, and pine forest grew on the bogs. Again came a rainy period. The pine forests were buried in peat. And during these last changes in our climate there came, probably, that part of our flora which is peculiar to our lowest southernmost regions."

"Our flora has acquired a uniform stamp, because some few species, which were insensible to the changes of climate, have little by little conquered a place which there is now no cause for giving up. But, here and there, on the friable slates in the mountain districts, on the moist mountain slopes and in the forest valleys, as also on wild rubble-slopes, under steep walls of rock, on the heather-tracts of the west coast, on the slate rocks in the Christiania fiord, on the cliffs of the coast in the province of Christianssand, on the gravel and sand of the edge of the shores, we find remains from these days gone by, remains which relate how our country received, little by little, the vegetation that now clothes our mountains and valleys."

With few and doubtful exceptions all the plants of Norway are also found beyond the borders of the country; there are peculiar forms, but none distinct enough from its congeners to be unequivocally recognized as a distinct species. Such forms, as Prof. Blytt remarks, are what would be expected under the vicissitudes which he refers to. A species with an unbroken and continuous hold and full occupation of a region has little chance for fixing variations. But forms reduced to isolation by stress of circumstances, having no opportunity to cross with their brethren, will preserve and have the best opportunity to develope their individual peculiarities, fix them into a race or subspecies, and when a turn of the climate favors them may multiply and occupy the district with a race markedly different from the common type of the species elsewhere. A. G.

4. *Genera Plantarum*, . . . *auctoribus* G. BENTHAM et J. D. HOOKER. Vol. secundum, sistens Dicotyledonum Gamopetalarum Ordines XLV, Caprifoliaceas—Plantagineas. Londoni, 1873-1876.—This is the title page, somewhat shortened, of the second volume of this noble work, of which the first part, 533 pages, was issued in the spring of 1873, and the second—bringing the volume

up to 1279 pages, and the subject to the end of the *Gamopetalæ*, followed by some corrections and a good index—is now happily before us. Our scattered botanists will be glad to know this; also that the third and final volume, according to present prospects, will not be long delayed. Considering the extent and formidable character of this undertaking, and the large amount of other work which both authors have upon their hands, the rate of progress thus far is remarkable. The work has the names of two well-known London publishers upon the title page, Reeve & Co., and Williams and Norgate, and can be had through the ordinary channels of the trade. If any of our botanists who desire to order it have any difficulty in the way of procuring it through the booksellers, they are at liberty to communicate with the writer of this announcement. A. G.

5. *Botany of California.* Vol. I. *Polypetalæ*, by W. H. BREWER and SERENO WATSON. *Gamopetalæ*, by ASA GRAY. 1876. —This long-expected volume has at length made its appearance. It fills 628 pages, besides the 25 pages of prefatory matter, and is uniform with the publications of the Geological Survey of the State of California, of which it was intended to form a part, and may still do so, if the State soon takes it up. There is no necessity of appending to this announcement a history of this work. Suffice it to say that the present volume—the larger part of the projected work—is now brought out and placed within the reach of botanists and those interested in the results of botanical investigations, by the indomitable perseverance and energy of the State Geologist, Prof. Whitney, and by the considerate liberality of the following gentlemen, citizens of California, who furnished the means for carrying it on after the State abandoned it, viz: *Leland Stanford, D. O. Mills, Lloyd Tevis, J. C. Flood, Charles McLaughlin, R. B. Woodward, William Norris, John O. Earl, Henry Pierce, Oliver Eldredge, S. Clinton Hastings.* The scientific gentlemen engaged have done their part, and those who have done the State's duty in the premises are understood to be ready to supply the necessary means for carrying the second and concluding volume through the press. When this is done it may be said that no other State in the Union has such a well-ordered and complete Flora.

The Introduction, by Prof. Whitney, giving some account of the undertaking, fills three pages. A note supplies some special explanation of the plan of the work; the remainder of the Preface is occupied by two keys to the Natural Orders herein comprised; first, an analytical artificial key; second, a synoptical key, giving the orders in their sequence, or nearly so, and with reference to exceptional cases and anomalies. The two may supplement each other, and greatly assist the ordinary student or amateur botanist, who cannot be expected to have the characters of the orders well in hand, nor to recognize aberrant members at the first glance. Such keys are very useful, almost indispensable; but it is impossible to make them perfect so as to provide for every case. They

should be used as helps, not as an absolute reliance or as a mechanical substitute for brains.

The *Polypetalæ* occupy 276 pages; the *Gamopetalæ*, 346. Without reference to the scientific merits of this work—of which others will judge—we are free to pronounce its plan and its typography as unsurpassedly excellent. A. G.

6. *Quarterly Bulletin of the Nuttall Ornithological Club, Cambridge, Mass.*, vol. I, No. 1, April, 1876. 28 pp. 8vo, with one beautifully colored plate.—The annual subscription for this valuable publication is only one dollar, or 30 cents per number. It is to be issued quarterly in numbers of 16 pages.

IV. Astronomy.

1. *Astronomical Tables, comprising logarithms from* 3 *to* 100 *places;* by Henry M. Parkhurst. New York, 1876.—We have received a copy of these tables, now issued by the author though his plan for the whole work is still but partially worked out. The first part of the book of 224 pages contains about 70 tables. Elaborate tables are given to aid in computing logarithms to a large number of decimals, to 8, 10, 15, 20, 30, 60, and even 100 places, by a method which the author claims as new. Ordinary four-figure tables of logarithms, addition and subtraction logarithms, log. sines, tangents, &c. Numerical tables, as primes, least divisors, reciprocals, multiples, squares, &c., follow, which with the logarithms make about three-fourths of the tables. The remainder consists of about 40 astronomical tables of various kinds. In Parts 2d and 3d are explanations of the use and the theory of the tables. They are full of interesting and valuable suggestions and information from the author's experience as an amateur observer. They also contain large numbers of formulas for astronomical computation. To many the use of phonetic print will be repulsive, but we wish success to any effort to simplify the spelling of English words. The author's occupation as a stenographer has led him to condense the tables and use abbreviations at the expense, in some cases, of clearness. He has certainly succeeded in putting into a moderate size a large variety of useful matter.

V. Miscellaneous Scientific Intelligence.

1. *Probability of error in writing a series of numbers.* Letter to the editors, dated St. Louis, May 10, 1876.—Not long since while writing logarithms that were being read to me, I observed that the probability of error in writing the numbers appeared to be much less at the extremities of the number, than in the middle. This has been investigated quite at length with numbers of from five to ten digits. It is found that the probability of error is in all cases expressed by the terms of the expanded binomial

$$(a+b)^n$$

where n is a function of the number of digits. Thus far a and b

have always been unequal, with all the persons yet experimented upon. The probability of error is greatest just after the middle of the number.

This has led to an interesting investigation on the power of memory. Allowing definite intervals (t) of time to elapse between the giving and the writing of the number, and it is evident that the number of errors will increase with the value of t.

In order to aid the experimenter in abstaining from mentally repeating the number which he is to write, he is allowed to determine the value of (t) by counting the beats of a seconds pendulum. The investigation is yet in progress, but enough has been done to develop the fact that the relation between the number of figures (per 100) written correctly, and the values t, is a logarithmic one. It is the same as the function expressing the decrease in the amplitude of the beats of a pendulum, in time, as due to a resisting medium. F. E. NIPHER.

2. *Record of Science and Industry for* 1875; edited by SPENCER F. BAIRD. 646 pp. 8vo. New York, 1876. (Harper & Brothers.)—Professor Baird's scientific annual for 1875 has recently been issued. It is a work not only for men of science, but also for all who would inform themselves as to the new facts and discoveries in science and the practical arts, and learn something of the world's progress in knowledge.

3. *Transactions of the Connecticut Academy*, vol. III, part I. —This volume contains: I. A report on the dredging in the region of St. George's Banks in 1872, by S. I. Smith and O. Harger, with 8 plates; II. Descriptions of new Hydroids by S. F. Clark, with 2 plates; III. On the Chondrodite of Brewster, N. Y., by E. S. Dana, with 3 plates—the paper which was condensed for volume ix of this Journal; IV. On the Transcendental Curves $\sin y \sin my = a \sin x \sin nx + b$, by H. A. Newton and A. W. Phillips, with 44 plates, containing photo-lithographic transfers of 148 different examples of the curves; V. On the equilibrium of Heterogeneous Substances, First Part, by J. Willard Gibbs, a profound paper, occupying 150 pages, putting new methods of analysis in the hands of mathematicians and physicists.

Notes of the following works are unavoidably deferred:

Bulletin of the U. S. Geological Survey of the Territories. Vol. II, No. 3.

Geographical Distribution of Plants. Part II. Plants in their wild state; by Charles Pickering, M.D., author of The Races of Men. 524 pp. 4to. 1876.

Report on the Geology of the Eastern portion of the Uinta Mountain, and a region of Country adjacent thereto; by J. W. Powell. 218 pp. 4to, with an atlas. Washington. Department of the Interior. 1876.

Geological and Natural History Survey of Minnesota. Fourth Annual Report, for 1875; by N. H. Winchell, State Geologist. 80 pp. 8vo. St. Paul, 1876.

Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Region. 630 pp. 4to, with 45 plates. 1876. Vol. ix of the Quarto Series of the U. S. Geol. Survey of the Territories in charge of Dr. F. V. Hayden. Department of the Interior.

OBITUARY.

ANGELIN, the eminent Swedish Paleontologist, died at Stockholm on the 13th of February, aged seventy years.

E. BILLINGS, the able Paleontologist of the Canadian Geological Survey, has recently died.

APPENDIX.

ART. IX.—*On a new Crinoid from the Cretaceous formation of the West;* by GEORGE BIRD GRINNELL. With Plate IV.

AMONG the many interesting fossils recently received from the West by the Yale College Museum, is a new Crinoid from the Cretaceous of the Uinta Mountains and of Kansas. No crinoids from the American Cretaceous have hitherto been described, and for the discovery of this species we are indebted to Prof. O. C. Marsh, who has done so much to bring to light the geological treasures of the West.

The Crinoid in question belongs to the group *Astylidæ*, or free Crinoids, and, as suggested by Prof. Marsh in his earliest paper on the Geology of the Uinta Mountains,* is allied to the genus *Marsupites* of Miller. From that genus, however, it differs widely in the number and arrangement of its plates, in having apparently ten arms, and in other characters; and it is possible that an examination of additional material may show it to be the type of an entirely new group. This point, however, cannot at present be determined.

Uintacrinus socialis, gen. et sp. nov.

The body as seen is somewhat discoidal in form, owing to pressure, but in life was evidently subglobose. The basal and subradial plates are imperfectly known. In the most perfect specimen, (figure 1,) three radial plates are found, irregularly pentagonal, hexagonal, or heptagonal in form, and varying considerably in size. Of these, the third or superior seems to be always the largest and most regular in outline. It is heptagonal, and two of its longest sides slope downward from the superior angle. The second radial is about equal in size to the first. All are wider than high. The third radial bears on each of its superior sloping sides in immediate succession five secondary radials, irregularly pentagonal or hexagonal in shape, and all wider than high. The fifth of these approaches in shape the proximal armpiece, to which it gives immediate support.

The arm pieces are thin, and horizontally compressed from without inward, their shape being sub-elliptical. The arms give support to delicate pinnulæ, or tentacles, for a portion of their

* This Journal, vol. i, p. 191, March, 1871.

length, though at what point these first appear is as yet uncertain. The more distant arm pieces show, when the articular surfaces can be examined, a distinct radiate structure, and there are traces, in some of the pieces which are exposed, of a canal, which in life may have given passage to the "axial cord" (nerve) of Dr. Carpenter. There is also to be seen on the inner side of several of the more distant arm pieces a deep depression, the radial furrow, which gives to the plates a subcrescentoid shape. These characters cannot be well made out, as all the pieces which show them are badly weathered. The arm pieces diminish very gradually in size, and the arms are long. On one of the slabs they have been traced continuously for a distance of eight inches with but little change in size, and it seems probable that in life the spread of the outstretched arms may have been two feet or more.

The interradial arms are irregular in shape, somewhat contracted near the middle, becoming wider above and below. They consist of about sixteen large irregular plates varying widely in size, and of from sixteen to twenty smaller ones, placed high up between the arms, and in part concealed by them. The former range from pentagonal to octagonal in shape, and although the specimens are not sufficiently perfect to enable the arrangement to be determined with certainty, it seems to be as follows: commencing below, opposite the first radial is a single plate; next above, in line with the second radial are two; and then three opposite the third. Succeeding these, and lying between the first of the secondary radials, is a single wide octagonal plate, and above this eight others, somewhat irregular, extending up in pairs to between the fifth secondary radials (figure 1). Immediately above these eight follow the smaller plates, four or six in a horizontal series, diminishing rapidly in size, and soon disappearing beneath the arms. A very small quadrangular plate is inserted between the first and second radials and the interradial plates which are opposite these. It is not certain, however, that this arrangement is altogether constant. In fact the other side of the specimen from which this is taken, though too imperfect for use, suggests a larger interradial arm, and hence, a probable difference in the number of the plates.

The interaxillary areas consist of about ten large plates and from sixteen to twenty smaller ones, the latter arranged much as in the interradial arm. Of the larger ones, several of the lowermost are much weathered, and their shape and arrangement cannot be positively ascertained from the specimens at hand. The inferior plate is the largest. It is higher than wide, octagonal, and somewhat shield-shaped, apparently supporting, on its superior sloping sides two high and rather narrow pieces, which in turn, give support to two small subtriangular plates.

Above these are four others in pairs, and these are followed by the smaller ones in fours, becoming rapidly less in size, as in the interradial arm.

The specimens are found in a soft light-colored limestone, and a considerable mass of the rock is often made up of their remains, as shown in the accompanying plate, figure 2, indicating that the individuals of this species lived together in large numbers. To this fact the specific name refers. It is needless to remark at length on the great interest which attaches to this species, the first crinoid known from the Cretaceous of the new world. The fact that it lacks a stem, thus resembling the genus *Marsupites* from the English chalk, suggests the advance made by some of the Crinoids that survived until the Cretaceous, over the older forms that lived in Paleozoic time.

The first specimen of the species here described was discovered by Prof. Marsh in the Cretaceous of the Uinta mountains during the autumn of 1870. It was found associated with the scales of a *Beryx*, and *Ostrea congesta* Con., typical Cretaceous forms. The species is apparently rare in this locality, as a diligent search by the writer and other members of the expedition failed to bring to light any more specimens. Others have since been received from the Cretaceous of Kansas, where they were associated with the Odontornithes, Pterodactyls and Mosasauroid reptiles of that formation.

The writer is under many obligations to Prof. Marsh for the opportunity of examining these specimens, and for most valuable suggestions in regard to the literature of the subject.

YALE COLLEGE, New Haven, June, 1876.

Explanation of Plate.

Figure 1. *Uintacrinus socialis.* Side view of a specimen showing radials and interradial arm. Natural size.

Figure 2. *Uintacrinus socialis.* Side view of a weathered specimen showing radials, interaxillary area, arms and pinnulæ.

a and *b*. Two of the more distant arm pieces magnified, showing the radial furrow, and indistinctly, the grooves radiating from the center.

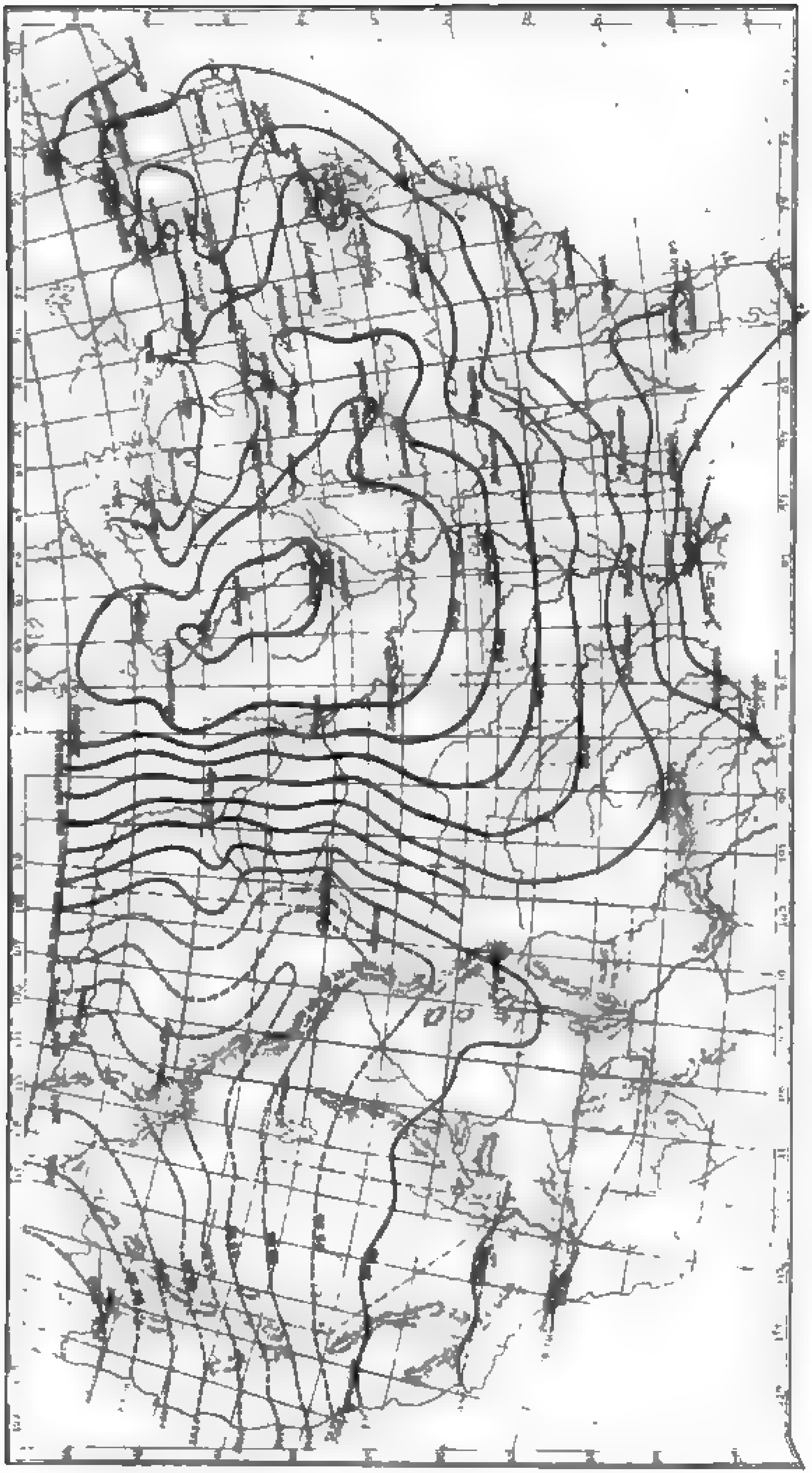
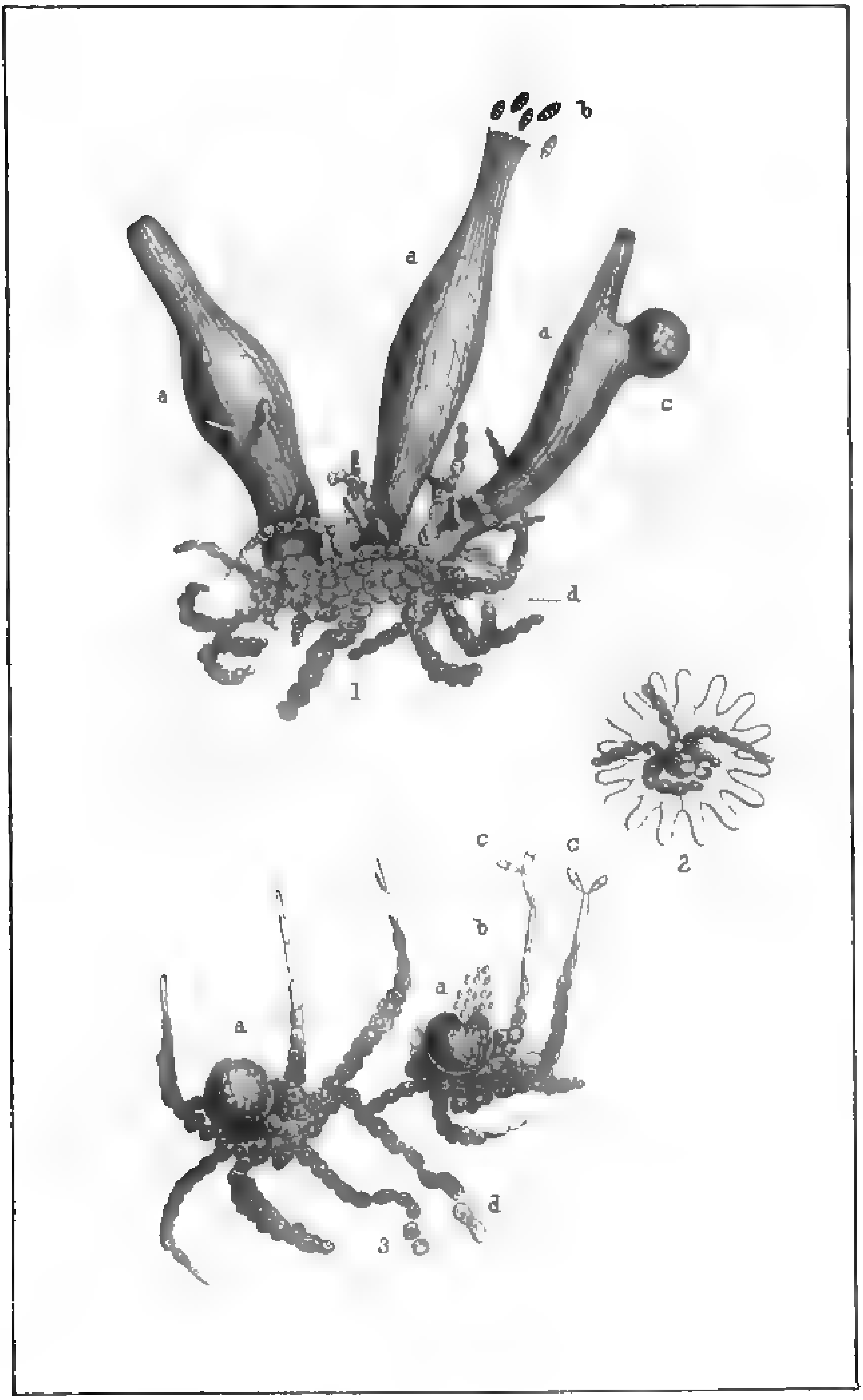
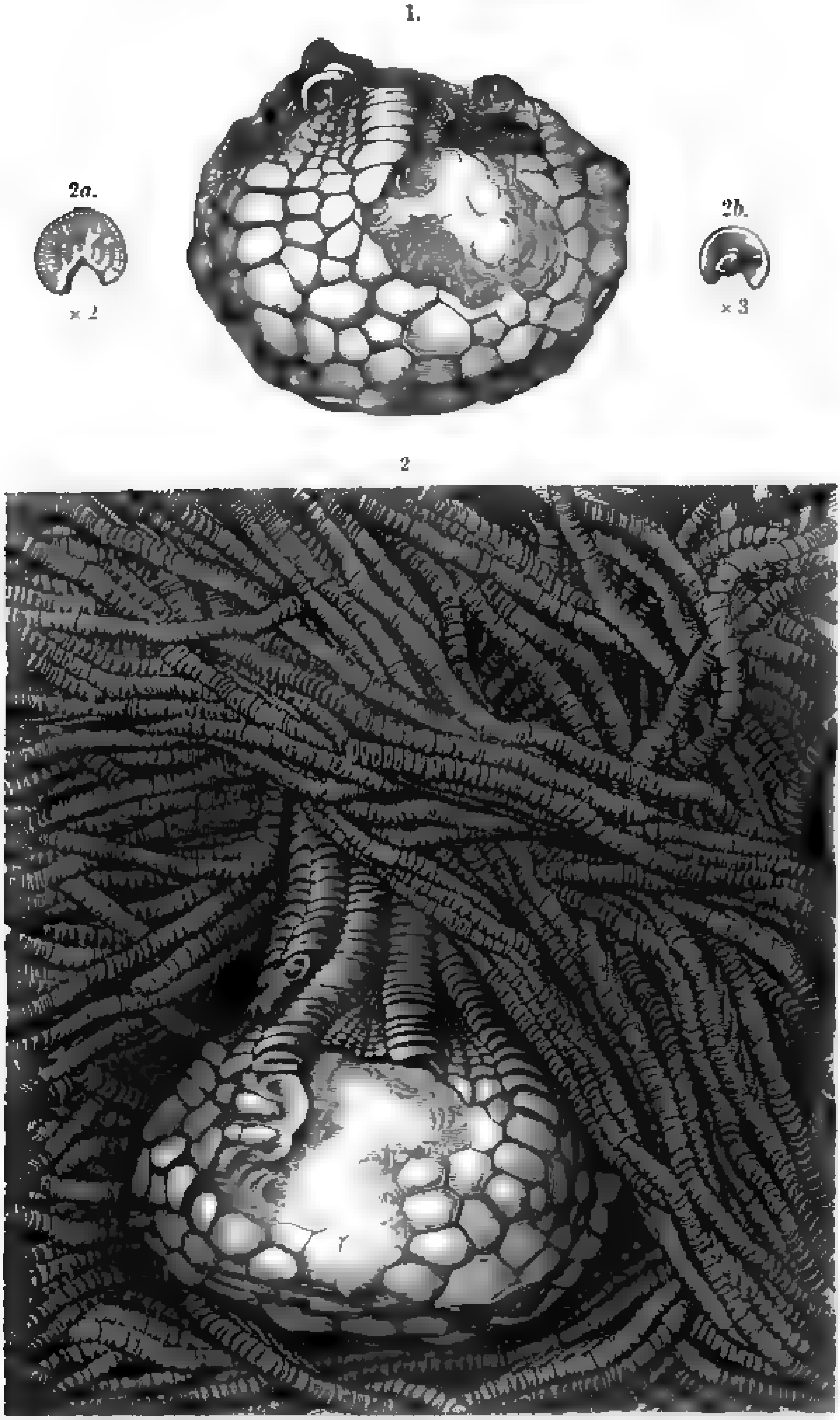


PLATE III



T. Sinclair & Son, lith. Phila.



UINTACRINUS SOCIALIS. Grinnell.

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JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. X.—*The Colorado Plateau Province as a Field for Geological Study;* by G. K. GILBERT.

[Continued from page 24.]

[It has happened that the division of this paper into parts has interrupted the sense, and I shall therefore have to ask the reader who would understand this page to refer again to the figures on page 23 of this volume.

BETWEEN the Hurricane and Toroweap faults is contained the U′-in-ka-ret block. It is tilted slightly toward the east and is fifteen miles broad. Upon it stands a group of volcanic mountains, the lavas of which have risen through fissures in the block. Between the Toroweap and West Kaibab displacements is the Kan-ab′ block, thirty miles broad. It appears level in the east-west section, but has, in common with all the other blocks of the sketch, a gentle dip to the north. Its cap of Carboniferous limestone is divided in the foreground by the cañon of Kanab creek, and fifty miles away it passes beneath Triassic sandstones. The Kaibab block stands highest of all. The strata, which for fifteen miles run level on its summit, are flexed downward at both margins, on one side to the Kanab block, and on the other to the Marble Cañon block. Its upper surface is the Kaibab Plateau. The Marble Cañon block is thirty miles broad. On the line of the section its highest bed is of Carboniferous age, but a few miles farther north it retains a heavy bed of Trias, which rises 2000 feet higher and constitutes the Paria Plateau.

The features of the region pictured to which I wish especially to call attention, are:

First, that there are no anticlinals and no synclinals, but only monoclinals and faults;

Second, that the throws of the displacements are not all on the same side;

Third, that the visible portion of the earth's crust is divided into great blocks, which have changed their relative and absolute altitudes by thousands of feet, without losing their individuality.

The structure of this region is an unusually pure example of a type that, with various modifications, prevails throughout the Plateau region, and Major Powell has taken a name from the locality and called it the *Kaibab structure.* We cannot study the embryology of mountains by observing the progress of an individual, but it is possible, by the comparison of many individuals in various stages of development, to learn something of the manner of mountain growth, and, studying the subject in this way, the conclusion has been reached that many mountain ranges are built upon the plan of the Kaibab Plateau. The essential feature of the plan is the upward movement *en masse* of a great body of rock between two planes of displacement. A *plateau* is thus produced, from which mountain forms are carved by the ordinary processes of erosion. Evidences of such a plan have been found in nearly all the mountains of the upper basin of the Sevier River, in some of the ranges of the Great Basin, by Major Powell in the Uintah range, and by Mr. Marvine in the Front and Medicine Bow ranges of Colorado. Few of these cases are so simple as that of the Kaibab Plateau. In some the block has been lifted more on one side than on the other, so as to acquire a dip; in other cases there are a number of blocks of different elevation in the same range; in yet other, the blocks are somewhat curved.

I shall not attempt to enumerate the variations of the type, which arise in these several ways. The purpose of the illustration is accomplished, if I have shown that the exceptional exhibition, in the Plateaus, of displacements which are simple and easy of comprehension, has already led to the recognition of a new class of mountain structures, or at least of a class so little known heretofore that it has not found place in the manuals of geology.

When the displacements of the region have all been worked out, it will be possible to construct a model which shall exhibit the structure of at least one hundred and fifty thousand square miles of the earth's crust, showing the form and position of each of the blocks which compose it; and I conceive that such a model, or an equivalent presentation of the same material by some other method, will not be inferior in value to any single contribution that has been made to our knowledge of the results of orographic movements.

Mountain building by eruption.—The studies, which the Plateaus afford in the phenomena of eruption, are scarcely less interesting and important than those of uplift and downthrow; but they have received less attention up to the present time. It happens that a number of extinct eruptive mountains stand near the cañons of the Colorado River. The country about them has suffered and is suffering rapid denudation, and not only are their bases nearly free from detritus, but their flanks are so deeply scored, and their summits are so degraded, that their internal structure is exhibited. Those that are best known have been found to be composed chiefly of sedimentary strata, protected from denudation by the superior durability of the eruptive rocks with which they are associated.

In the U′-in-ka-ret mountains Major Powell found a mass of undisturbed strata, which had been preserved from erosion by a mantle of lava, while the surrounding country was degraded more than a thousand feet. The eruptions were extended through a long period of time, and the successive outflows mantled the flanks of the surviving strata almost as thoroughly as they did the summit, so as to give the appearance, at first glance, of a range made up entirely of volcanic matter.

In the Henry Mountains the strata are not undisturbed, but have been lifted into a number of bubble-shaped domes, one for each individual mountain of the group. Each dome has been fractured at top, and divided by fissures radiating from the center toward the sides, and all the fissures have been filled by molten rock. Moreover the strata have in many places cleaved apart, and lava sheets have been interleaved with them.

Doubtless the intrusion of these dikes and sheets was accompanied by extrusion, but none of the extruded masses appear to have survived the subsequent erosion. The mountains as they stand are simply domes of curved strata. each traversed by a plexus of crystalline dikes.

Similar in structure to the Henry Mountains are Navajo Mountain, Sierra la Sal, and Sierra Abajo. Mount San Francisco, and perhaps Mount Taylor, are related to the Uinkarets. This enumeration includes but a small portion of the volcanic mountains of the district, and to the two types of structure mentioned, several others might be added. But the mountains of the Uinkaret and Henry types are most favorably situated for study, and at the same time diverge most widely in character from those with which geologists are already familiar.

Stratigraphy.—In the stratigraphy of the Plateaus attention has thus far been confined to questions that are chiefly of local importance, but a thorough study of the phenomena which are accessible can hardly fail to throw light on the

principles of sedimentation. In the region of cañons a single bed can be followed, upon one continuous outcrop, for hundreds of miles, and every modification that it undergoes can be traced step by step. Moreover, by reason of the ramifications of cañons, it is frequently possible to trace a bed toward all points of the compass, so as to learn its changes, not merely along a simple line, but throughout an extended area. With such exposures, unconformity cannot escape detection, and the history of a system of sediments can be made out with a completeness that surely cannot be excelled elsewhere.

Part II. EROSION.

It remains to indicate the scope of the material bearing upon the subject of erosion, and with that intent I will discuss certain problems which the region has propounded. The first may be called

The Problem of the Cañons.

The deep gorges which so facilitate the examination of the strata and of their displacements, are themselves of interest as monuments of erosion. To account for their existence and unravel their history is to review the laws of erosion with great wealth of illustration. Results so extreme can have been produced only under conditions equally extreme; and natural laws are often best tested and exemplified by the consideration of their operation under exceptional circumstances. Already the problem of the cañons has been attacked, and I cannot better demonstrate its radical value than by presenting the present aspect of the case. For this purpose it is necessary to give a summary statement of the processes of erosion and of the conditions which determine its rate. The matter is so complex that this cannot be done briefly without the omission of the less important factors, and in undertaking it I shall take the liberty of either disregarding or slighting all considerations which have not an important bearing on the problem in question.

In order to analyse sub-aerial erosion, we must consider it (A) as consisting of parts, and (B) as modified by conditions.

A. All indurated rocks and most earths are bound together by a force of cohesion, which must be overcome before they can be divided and removed. The natural processes by which the division and removal are accomplished make up erosion. They are called disintegration and transportation.

Transportation is chiefly peformed by running water.

Disintegration is naturally divided into two parts. So much of it as is accomplished by running water is called corrasion, and that which is not, is called weathering.

Stated in their natural order, the three general divisions of the process of erosion are (1) *weathering*, (2) *transportation*, and (3) *corrasion*. The rocks of the general surface of the land are disintegrated by *weathering*. The material thus loosened is *transported* by streams to the ocean or other receptacle. In transit it helps to *corrade* from the channels of the streams other material, which joins with it to be transported to the same goal.

(1.) In weathering the chief agents of disintegration are solution, change of temperature, the beating of rain, and vegetation.

The great solvent of rocks is water, but it receives aid from some other substances, of which it becomes the vehicle. These substances are chiefly products of the formation and decomposition of vegetable tissues. Some rocks are disintegrated by their complete solution, but the great majority are divided into grains by the solution of a portion; and fragmental rocks usually lose by solution the cement merely, and are thus reduced to their original, incoherent condition.

The most rigid rocks are cracked by sudden changes of temperature; and the crevices thus begun, are opened by the freezing of the water within them. The coherence of the more porous rocks is impaired and often destroyed by the same expansive force of freezing water.

The beating of the rain overcomes the feeble coherence of earths, and assists solution and frost by detaching the particles which they have partially loosened.

Plants often pry apart rocks by the growth of their roots, but their chief aid to erosion is by increasing the solvent power of percolating water.

(2.) A portion of the water of rains flows over the surface and is quickly gathered into streams. A second portion is absorbed by the earth or rock on which it falls, and after a slow underground circulation reissues in springs. Both transport the products of weathering, the latter carrying dissolved minerals, and the former chiefly undissolved.

Transportation is also performed by currents of air, and by the direct action of gravity; but in the present discussion it will not be necessary to consider these accessory agents.

(3.) In corrasion the agents of disintegration are solution and mechanical wear. Wherever the two are combined, the superior efficiency of the latter is evident; and in all fields of rapid corrasion the part played by solution is so small that it may be disregarded.

The mechanical wear of streams is performed by the aid of hard mineral fragments which are carried along by the current.

The effective force is that of the current; the tools are mud, sand, and bowlders. The most important of them is sand; it is chiefly by the impact and friction of grains of sand that the rocky beds of streams are disintegrated.

Streams of clear water corrade their beds by solution. Muddy streams act partly by solution, but chiefly by attrition.

Streams transport the combined products of corrasion and weathering. A part of the debris is carried in solution, and a part mechanically. The finest of the undissolved detritus is held in suspension; the coarsest is rolled along the bottom; and there is a gradation between the two modes. There is a constant comminution of all the material as it moves, and the work of transportation is thereby accelerated. Bowlders and pebbles, while they wear the stream-bed by pounding and rubbing, are worn still more rapidly themselves. Sand grains are worn and broken by the continued jostling, and their fragments join the suspended mud. Finally the detritus is all more or less dissolved by the water, the finest the most rapidly.

In brief, (1) weathering is performed by solution; by change of temperature, including frost; by rain beating; and by vegetation.

(2) Transportation is performed chiefly by running water.

(3) Corrasion is performed by solution, and by mechanical wear.

Corrasion is distinguished from weathering chiefly by including mechanical wear among its agencies, and the importance of the distinction will be apparent when we come to consider how greatly and peculiarly this agency is affected by modifying conditions.

In the region of cañons, the progress of corrasion has outstripped that of weathering, and to discover what conditions have determined this result, is to solve the problem of the cañons.

B. The chief conditions which affect the rapidity of erosion are (1) declivity, (2) character of rock, and (3) climate.

(1.) In general, *erosion is most rapid where the slope is steepest;* but weathering, transportation and corrasion are affected in different ways and in different degrees.

With increase of slope goes increase in the velocity of running water, and with that goes increase in its power to transport undissolved detritus.

The ability of a stream to corrade by solution is not notably enhanced by great velocity; but its ability to corrade by mechanical wear keeps pace with its ability to transport, or may even increase more rapidly. For not only does the bot-

tom receive more blows in proportion as the quantity of transient detritus increases, but the blows acquire greater force from the accelerated current, and from the greater size of the moving fragments. It is necessary, however, to distinguish the ability to corrade from the rate of corrasion, which will be seen further on to depend largely on other conditions.

Weathering is not directly influenced by slope, but it is reached indirectly through transportation. Solution and frost, the chief agents of rock decay, are both retarded by the excessive accumulation of disintegrated rock. Frost action ceases altogether at a few feet below the surface, and solution gradually decreases as the zone of its activity descends and the circulation on which it depends becomes more sluggish. Hence the rapid removal of the products of weathering stimulates its action, and especially that portion of its action which depends upon frost. If, however, the power of transportation is so great as to remove completely the products of weathering, the work of disintegration is thereby checked; for the soil, which weathering tends to accumulate, is a reservoir to catch rain as it reaches the earth, and store it up for the work of solution and frost, instead of letting it run off at once unused.

In brief, a steep declivity favors transportation and thereby favors corrasion. The rapid, but partial, transportation of weathered rock accelerates weathering; but the complete removal of its products retards weathering.

(2.) Other things being equal, *erosion is most rapid when the eroded rock offers least resistance;* but the rocks which are most favorable to one portion of the process of erosion, do not necessarily stand in the same relation to the others. Disintegration by solution depends in large part on the solubility of the rocks, but it proceeds most rapidly with those fragmental rocks of which the cement is soluble, and of which the texture is open. Disintegration by frost is most rapid in rocks which absorb a large percentage of water and are feebly coherent. Disintegration by mechanical wear is most rapid in soft rocks. Transportation is most favored by those rocks which yield by disintegration the most finely comminuted debris

(3.) The influence of climate upon erosion is less easy to formulate. The direct influences of temperature and rainfall are comparatively simple, but their indirect influence, through vegetation, is complex, and is in part opposed to the direct influence of rainfall.

Temperature affects erosion chiefly by its changes. Where the range of temperature includes the freezing point of water, frost contributes its powerful aid to weathering; and it is only where changes are great and sudden that rocks are cracked by their unequal expansion or contraction.

All the processes of erosion are affected directly by the amount of rainfall, and by its distribution through the year. All are accelerated by its increase and retarded by its diminution. When it is concentrated in one part of the year at the expense of the remainder, transportation and corrasion are accelerated, and weathering is retarded.

Weathering is favored by abundance of moisture. Frost accomplishes most when the rocks are saturated; and solution, when there is the freest subterranean circulation. But when the annual rainfall is concentrated into a limited season, a larger share of the water fails to penetrate, and the gain from temporary flooding does not compensate for the checking of all solution by a long dry season.

Transportation is favored by increasing water supply as greatly as by increasing declivity. When the volume of a stream increases, it becomes at the same time more rapid, and its transporting capacity gains by the increment to velocity as well as by the increment to volume. Hence the increase in power of transportation is more than proportional to the increase of volume.

It is due to this fact chiefly, that the transportation of a stream which is subject to floods is greater than it would be if its total water supply were evenly distributed in time.

The indirect influence of rainfall and temperature, by means of vegetation, has different laws. Vegetation is intimately related to water supply. There is little or none where the annual precipitation is small, and it is profuse where the latter is great and especially where the temperature is at the same time high, In proportion as vegetation is profuse the solvent power of percolating water is increased, and, on the other hand, the ground is sheltered from the mechanical action of rains and rills. The removal of disintegrated rock is greatly impeded by the conservative power of roots and fallen leaves, and a soil is invariably preserved. Transportation is retarded. Weathering by solution is accelerated up to a certain point, but in the end it suffers by the clogging of transportation. The work of frost is nearly stopped as soon as the depth of soil exceeds the limit of frost action. The force of rain-drops is expended on foliage. Moreover a deep soil acts as a distributing reservoir for the water of rains, and tends to equalize the flow of streams.

Hence the general effect of vegetation is to retard erosion; and since the direct effect of great rainfall is the acceleration of erosion, it results that its direct and indirect tendencies are in opposite directions.

In arid regions of which the declivities are sufficient to give thorough drainage, the absence of vegetation is accompanied by

absence of soil. When a shower falls, nearly all the water runs off from the bare rock, and the little that is absorbed is rapidly reduced by evaporation. Solution becomes a slow process for lack of a continuous supply of water, and frost accomplishes its work only when it closely follows the infrequent rain. Thus weathering is retarded, and transportation has its work so concentrated by the quick gathering of showers into floods, as to compensate, in part at least, for the smallness of the total rainfall from which they derive their power.

Hence in regions of small rainfall, surface degradation is usually limited by the slow rate of disintegration; while in regions of great rainfall it is limited by the rate of transportation. There is probably an intermediate condition, with moderate rainfall, in which a rate of disintegration greater than that of an arid climate is balanced by a more rapid transportation than consists with a very moist climate, and in which the rate of degradation attains its maximum.

Having examined the conditions of erosion separately, let us now group them in such combination as will help to an understanding of the cañons.

Over nearly the whole of the earth's surface there is a soil, and wherever this exists we know that the conditions are more favorable to weathering than to transportation. Hence it is true in general that the conditions which limit transportation are those which limit the general degradation of the surface.

To understand the manner in which this limit is reached, it is necessary to look at the process by which the work is accomplished.

Transportation and Comminution.—A stream of water flowing down its bed expends an amount of energy that is measured by the quantity of water and the vertical distance through which it descends. If there were no friction of the water upon its channel the velocity of the current would continually increase; but if, as is the usual case, there is no increase of velocity, then the whole of the energy is consumed in friction. The friction produces inequalities in the motion of the water, and especially induces subsidiary currents more or less oblique to the general onward movement. Some of these subsidiary currents have an upward tendency, and by them is performed the chief work of transportation. They lift small particles from the bottom and hold them in suspension while they move forward with the general current. The finest particles sink most slowly and are carried farthest before they fall. Larger ones are barely lifted, and are dropped at once. Still larger are only half lifted; that is, they are lifted on the side of the current and rolled over,

without quitting the bottom. And finally there is a limit to the power of every current, and the largest fragments of its bed are not moved at all.

There is a definite relation between the velocity of a current and the size of the largest bowlder it will roll. It has been shown by Hopkins that the weight of the bowlder is proportioned to the sixth power of the velocity. It is easily shown also that the weight of a suspended particle is proportioned to the sixth power of the velocity of the upward current that will prevent its sinking. But it must not be inferred that the total load of detritus that a stream will transport bears any such relation to the rapidity of its current. The true inference is, that the velocity determines the limit in coarseness of the detritus that a stream can move by rolling, or can hold in suspension.

Every particle which a stream lifts and sustains is a draft upon its energy, and the measure of the draft is the weight (weighed in water) of the particle, multiplied by the distance it would sink in still water in the time during which it is suspended. If, for the sake of simplicity, we suppose the whole load of a stream to be of uniform particles, then the measure of the energy consumed in their transportation, is their total weight multiplied by the distance one of them would sink in the time occupied in their transportation. Since fine particles sink more slowly than coarse, the same consumption of energy will convey a greater load of fine than of coarse.

Again, the energy of a clear stream is entirely consumed in friction on its bottom; and the friction bears a direct relation to its velocity. But if detritus be added to the water, then a portion of its energy is diverted to the transportation of the load; and this is done at the expense of the friction upon the bottom, and hence at the expense of velocity. As the energy expended in transportation increases, the velocity diminishes. If the detritus be composed of uniform particles, then we may also say that as the load increases, the velocity diminishes. But the diminishing velocity will finally reach a point at which it can barely transport particles of the given size, and when this point is attained, the stream has its maximum load of detritus of the given size. But fine detritus requires less velocity for its transportation than coarse, and will not so soon reduce the current to the limit of its efficiency. A greater per cent of the total energy of the stream can hence be employed by fine detritus than by coarse.

Thus the capacity of a stream for transportation is enhanced by comminution in two ways. Fine detritus, on the one hand, consumes less energy for the transportation of the same weight, and on the other, it can utilize a greater portion of the stream's energy.

It follows, as a corollary, that the velocity of a fully loaded stream depends (*ceteris paribus*) on the comminution of the material of the load. When a stream has its maximum load of fine detritus, its velocity will be less than when carrying its maximum load of coarse detritus; and the greater load corresponds to the less velocity.

It follows also that a stream which is supplied with heterogeneous debris will select the finest. If the finest is sufficient in quantity, the current will be so checked by it, that the coarser cannot be moved. If the finest is not sufficient, the next grade will be taken, and so on.

Transportation and Declivity.—To consider now the relation of declivity to transportation we will assume all other conditions to be constant. Let us suppose that two streams have the same length, the same quantity of water, flow over beds of the same character, and are supplied to their full capacities with detritus of the same kind; but differ in the total amount of fall. Their declivities, or rates of fall, are proportional to their falls. Since the energy of a stream is measured by the product of its volume and its fall, the relative energies of the two streams are proportional to their falls, and hence, proportional to their declivities. The velocities of the two streams, depending as we have seen above, on the character of the detritus which loads them, are the same; and hence the same amount of energy is consumed by each in friction on its bed. And since the energy which each stream expends in transportation is the residual after deducting what it spends in friction from its total energy, it is evident that the stream with the greater declivity will not merely have the greater energy, but will expend a less per cent of it in friction and a greater per cent in transportation.

Hence declivity favors transportation in a degree that is greater than its simple ratio.

[There are two elements of which no account is taken in the preceding discussion, but which need to be mentioned to prevent misapprehension, although they detract in no way from the conclusions.

The first is the addition which the transported detritus makes to the energy of the stream. A stream of water charged with detritus is at once a compound and an unstable fluid. It has been treated merely as an unstable fluid requiring a constant expenditure of energy to maintain its constitution; but looking at it as a compound fluid, it is plain that the energy it developes by its descent, is greater than the energy pertaining to the water alone, in the precise ratio of the mass of the mixture to the mass of the simple water.

The second element is the addition which the detritus makes to the friction of the stream. The coefficient of friction of the compound stream upon its bottom will always be greater than that of the simple stream of water, and hence for the same velocity a greater amount of energy will be consumed.

It may be noted in passing, that the energy which is consumed in the friction of the detritus on the stream bed, accomplishes as part of its work the mechanical corrasion of the bed.]

Transportation and quantity of water.—The friction of a stream upon its bed depends on the character of the bed, on the area of the surface of contact, and on the velocity of the current. When the other elements are constant, the friction varies directly with the area of contact. The area of contact depends on the length and form of the channel, and on the quantity of water. For streams of the same length, and same form of cross-section, but differing in size of cross-section, the area of contact varies directly as the square root of the quantity of water. Hence, *celeris paribus*, the friction of a stream on its bed, is proportioned to the square root of the quantity of water. But, as stated above, the total energy of a stream is proportioned directly to the quantity of water. And also, the total energy is equal to the energy spent in friction, plus the energy spent in transportation. Whence it follows, that if a stream change its quantity of water without changing its velocity or other accidents, the total energy will change at the same rate as the quantity of water, the energy spent in friction will change at a less rate, and the energy remaining for transportation will change at a greater rate.

It follows, as a corrollary, that the running water which carries the debris of a district, loses power by subdivision toward its sources; and that, unless there is a compensating increment of declivity, the tributaries of a river will fail to supply it with the full load which it is competent to carry.

It is noteworthy also, that the obstruction which vegetation opposes to transportation, is especially effective in that it is applied at the infinitesimal sources of streams, where the force of the running water is least.

A stream which can transport debris of a given size, may be said to be *competent* to such debris. Since the maximum particles which streams are able to move are proportioned to the sixth powers of their velocities, competence depends on velocity. Velocity, in turn, depends on declivity and volume, and (inversely) on load.

In brief, the capacity of a stream for transportation is greater for fine debris than for coarse.

Its capacity for the transportation of a given kind of debris is enlarged in more than simple ratio by increase of declivity; and it is enlarged in more than simple ratio by increase of volume.

The competence of a stream for the transport of debris of a given fineness, is limited by a correspondent velocity.

The *rate* of transportation of debris of a given fineness, may equal the capacity of the transporting stream, or it may be less. When it is less, it is always from the insufficiency of supply. The supply which is furnished by weathering is never available unless the degree of fineness of the debris brings it within the competence of the stream at the point of supply.

The chief point of supply is at the very head of the flowing water. The rain which falls on material that has been disintegrated by weathering, begins, after it has saturated the immediate surface, to flow off. But it forms a very thin sheet; its friction is great; its velocity is small; and it is competent to pick up only particles of exceeding fineness. If the material is heterogeneous, it discriminates and leaves the coarser particles. As the sheet moves on, it becomes deeper, and soon begins to gather itself into rills. As the deepening and concentration of water progresses, either its *capacity* increases and the load of fine particles is augmented, or, if fine particles are not in sufficient force, its *competence* increases, and larger ones are lifted. In either case the load is augmented, and, as rill joins with rill, it steadily grows, until the accumulated water finally passes beyond the zone of disintegrated material.

The particles which the feeble initial currents are not competent to move, have to wait either until they are subdivided by the agencies of weathering, or until the deepening of the channels of the rills so far increases the declivities, that the currents acquire the requisite velocity, or until some fiercer storm floods the ground with a deeper sheet of water.

Thus rate of transportation, as well as capacity for transportation, is favored by fineness of debris, by declivity, and by quantity of water. It is opposed chiefly by vegetation, which holds together that which is loosened by weathering, and shields it from the agent of transportation in the very place where that agent is weakest.

When the current of a stream gradually diminishes in its course—as, for example, in approaching the ocean—the capacity for transportation also diminishes; and so soon as the capacity becomes less than the load, precipitation begins,—the coarser particles being deposited first.

Corrasion.—If a stream has no load of detritus, it corrades only by solution. If it is loaded to its full capacity, it does

not corrade; it is on the verge between corrasion and deposition. Only with a partial load does a stream wear its bottom.

The rapidity of mechanical corrasion depends on the hardness, size, and number of transient fragments, on the hardness of the rock-bed, and on the velocity of the stream. The blows which the moving fragments deal upon the stream-bed are hard, in proportion as the fragments are large and the current is swift. They are most effective when the fragments are hard and the bed-rock is soft. Their number is increased, up to a certain limit, by the increase of the load of the stream; but when the fragments become greatly crowded at the bottom of a stream, their force is partially spent among themselves, and the bed-rock is in the same degree protected. For this reason, and because increase of load causes retardation of current, it is probable that the maximum work of corrasion is performed when the load is far within the transporting capacity.

The element of velocity is of double importance, since it determines, not only the speed, but, to a great extent, the size of the pestles which grind the rocks. The coefficients upon which it in turn depends, namely, declivity and quantity of water, have the same importance in corrasion that they have in transportation.

Let us now direct our attention to the region of the cañons.

The Plateau province lay beneath the ocean up to the close of the Mesozoic age. In early Cenozoic time it was nearly covered by fresh-water lakes, and was not greatly elevated.

In more recent epochs it has been very greatly, but unequally lifted, and the lakes have been drained. The erosion which began with the first lifting of a part above the ocean, and extended its area as the lakes disappeared, has progressed continually to the present time. The average total uplift has been about 12,000 feet; the mean altitude of the present surface is about 7,000 feet; and the difference is the mean amount of degradation. While 5,000 feet have been removed from the general surface, an amount greater by several thousand feet has been corraded by the rivers.

The greater tributaries of the Colorado have their sources in elevated mountains which are well supplied with rain. Their courses through the Plateaus traverse regions characterized by aridity.

On the uplands which border the cañons the supply of water is so small and the declivity is so great that weathering is less favored than transportation. No soil accumulates; vegetation is scant; and, for the lack of these, weathering is reduced to a minimum. The degradation of the surface is limited by the retarded weathering.

In the cañons corrasion is favored by a quantity of water which belongs to the mountain sources of the streams and not to the plateaus which they divide. It is favored by a great declivity of bed, for which it is indebted to the magnitude and recency of the uplift. It is favored by a moderate supply of debris, always sufficient for the work of excavation, but not so great as to consume the entire energy of the current.

The contrast between the degradation of the upland and the cutting of the water ways is strongest where the rocks are best fitted to resist disintegration. The rivers sink their channels into the land in a harmonious and interdependent system, and cannot excavate soft beds more deeply than hard. But the only downward limit to the degradation of the tables is the level of the draining river system; and the varying retardation which it suffers from the resistance of different rocks, is expressed in the varying height of the cañon walls.

A second problem which has arisen in the study of the erosion of the Plateaus may be called

The Problem of Waterfalls.

Where rivers descend a slope that is terraced by the alternation of hard and soft strata, they are apt to leap from the edges of the hard beds in waterfalls. But the Colorado, notwithstanding the structure of its bed presents the most favorable conditions, makes no leap. At the head of Marble Cañon, for instance, the river crosses a great bed of limestone, lying nearly level and underlaid by a great bed of friable sandstone. The limestone resists all erosive agents as strongly as does the Niagara limestone, and the sandstone yields to them as easily as does the Niagara shale. But, instead of plunging from one to the other in a great cataract, the Colorado cuts the two with nearly equal grade of channel. Its average descent in the hard rock is ten feet to the mile, and in the soft, less than five feet.

It is evident that for the production of waterfalls some condition is involved beside that of the constitution of the rock-system which the stream traverses,—some condition that pertains to the constitution of the stream itself. Such a condition is to be found in the relation of corrasion to transportation.

Let us suppose that a stream, endowed with a constant supply of water, is at some point continuously supplied with as great a load as it is capable of carrying. For so great a distance as its velocity remains the same, it will neither corrade nor deposit, but will leave the grade of its bed unchanged. But if in its progress it reaches a place where a less declivity of bed gives a diminished velocity, its capacity for transportation will become less than the load, and part of the load will be depos-

ited. Or if in its progress it reaches a place where a greater declivity of bed gives an increased velocity, the capacity for transportation will become greater than the load, and there will be corrasion of the bed. In this way a stream, which has a supply of debris equal to its capacity, tends to build up the gentler slopes of its bed and cut away the steeper. It tends to establish a single, uniform grade.

Let us now suppose that the stream, after having obliterated all the inequalities of the grade of its bed, loses nearly the whole of its load. Its velocity is at once accelerated and corrasion begins through its whole length. Since the stream has the same declivity, and consequently the same velocity, at all points, its capacity for corrasion is everywhere the same. Its rate of corrasion, however, will depend on the character of its bed. Where the rock is hard, corrasion will be less rapid than where it is soft, and there will result inequalities of grade. But so soon as there is inequality of grade, there is inequality of velocity, and inequality of capacity for corrasion; and where hard rocks have produced declivities, there the capacity for corrasion will be increased. The differentiation will proceed until the capacity for corrasion is everywhere proportioned to the resistance, and no farther,—that is, until there is an equilibrium of action.

In general, we may say that a stream tends to equalize its work in all parts of its course. Its power inheres in its fall, and each foot of fall has the same power. When its work is to corrade and the resistance is unequal, it concentrates its energy where the resistance is great, by crowding many feet of descent into a small space; and diffuses it, where the resistance is small, by using but a small fall in a long distance. When its work is to transport, the resistance is constant, and the fall is evenly distributed by a uniform grade. When its work includes both transportation and corrasion, as is the usual case, its grades are somewhat unequal; and the inequality is greatest when the load is least.

The condition of the Colorado in respect to load, is midway between that of the Niagara and that of the Platte.

The water of the Niagara is nearly devoid of load. The lake of which it is the outlet gathers the detritus of all tributary streams, and only on the occasion of a great storm yields a small portion of it to the Niagara. The work of transportation is at a minimum, and the differentiation of slope dependent on rock structure reaches its maximum in a cataract.

The water of the Platte is supplied with all the load it can move. Major Powell, who has made a careful study of this river, ascribes its peculiar character to the fact that it flows through a region of unconsolidated strata. Its mean declivity

is as great as that of the Colorado, and it would have carved cañons of imposing depth, if only the material of its banks were sufficiently coherent to stand in walls. As it is, the loose sands of the bordering plains are washed and blown into the river, and, its energy being consumed in their transportation, the corrasion of its channel can proceed no faster than the general degradation of the plain. Having little work to perform beside the transportation of its load, it maintains an almost unvaried slope from the foot of the mountains to its mouth.

In that portion of the Colorado which is contained in the Plateau province, the load consumes a share of the energy of the stream and leaves to corrasion the remainder. The slopes of the stream-bed are varied, but not so greatly as those of the Niagara. Where the bed-rock is soft, the declivity is small. Where it is hard, the declivity is relatively great; but in the toughest hornblende rock the mean angle of slope does not exceed three degrees.

The Problem of Inconsequent Drainage.

There is a third problem of erosion now under investigation in the Plateaus that promises results of value and novelty. It was propounded by Major Powell, and is set forth on page 162, *et seq.*, of his "Exploration of the Colorado River." The question to be answered is: What is the relation of the drainage system of the Plateaus to the system of displacements? How far is it *consequent*, how far *antecedent*, how far *super-imposed?*

If a series of sediments, accumulated in an ocean or lake, be subjected to a system of displacements while still under water, and then be converted to dry land by elevation *en masse*, or by the retirement of the water, the rains which fall on it will inaugurate a drainage system perfectly conformable with the system of displacements. Streams will rise along the crest of each anticlinal, will flow from it in the direction of the steepest dip, will unite in the synclinals, and will follow them lengthwise. The axis of each synclinal will be marked by a watercourse; the axis of each anticlinal by a watershed. Such a system is said to be *consequent* on the structure.

If, however, a system of displacements affect a rock series after the series has become continental, it will have already acquired a system of waterways, and, unless the displacements are produced with unusual rapidity, the waters will not be diverted from their accustomed ways. The effect of local elevation will be to stimulate local corrasion, and each river that crosses an uplifted block will, inch by inch as the block rises, deepen its channel and valorously maintain its original course. It will result that the directions of the drainage lines will be

independent of the displacements. Such a drainage system is said to be *antecedent* to the structure.

There is one other case. Suppose a rock series that has been folded and eroded, to be again submerged, and to receive a new accumulation of unconforming sediments. Suppose further, that it once more emerges, and that the new sediments are eroded from its surface. Then the drainage system will have been given by the form of the upper surface of the superior strata, but will be independent of the structure of the inferior series into which it will descend vertically as the erosion progresses. Such a drainage system is said to be *super-imposed* upon the structure of the older series of strata.

A large share of the drainage of the Plateaus is not consequent. How much is super-imposed, and how much antecedent remains to be determined. With the solution of the problem are involved the determination of the antiquity and history of the Green and Colorado Rivers, and the physical history of the great Tertiary lakes; and we may hope that from its discussion will result the establishment of laws, by the aid of which it shall be possible, in other regions, to deduce facts of geological history from an examination of the relation of structure to drainage.

Summary.

The exposure of the rock structure in the Colorado Plateau province is exceptionally thorough. Soil and vegetation obstruct the view less than in other lands, and deep cañons exhibit natural sections in many directions.

The rock structure is simple but not the simplest. The strata have been displaced, but their displacement is so little complex that it can be clearly determined in kind and amount.

In virtue of the simplicity of structure and continuity of exposure, the geologist does not have to put fragmentary data together and grope for the general facts of which they form part, but is able to see all the parts combined in nature in visible wholes. Nothing need be left for doubtful interpretation where everything can be seen; and with the facts of structure conspicuous and beyond question, the mind is left free to search for causes.

The facilities for the study of single, simple displacements, isolated from other phenomena of the same order, are equalled by those for the study of eruptive mountains which are at once simple, isolated, and dissected by erosion.

To the student of stratigraphy are offered continuous exposures of great length.

To the student of erosion are exhibited the most distinguished monuments of its action; and he is given an opportu-

nity to partially isolate certain of the conditions which control the rapidity of erosive action, by viewing their influence where that influence is at a maximum.

No attempt has been made in this brief review to indicate the entire range of the subjects that will interest the geological student of the region. It was proposed rather to call attention to those categories of phenomena which give greatest promise of affording contributions to the body of principles which constitute the science of geology,—as distinguished from the phenomena which will merely enlarge the body of facts upon which its established principles are based. The progress of geological exploration has compassed so small a fraction of the earth's surface that the aspect of the science is modified, in greater or less degree, by the addition of each important mass of facts; and when the contribution from the Plateaus shall have been made, I am confident that its record will find a place in the history of geological progress.

Already the field has yielded to its students results which are new to them, and which are probably new to the world of science. Among them are a type of uplifted mountains, a type of eruptive mountains, a theory of waterfalls, and a classification of drainage systems.

ART. XI.—*Note on the development and homologies of the anterior brain-mass with Sharks and Skates;** by Prof. BURT G. WILDER.

IN the paper to which I have just referred† are some statements, partly original and partly based upon the authority of others, which, after a comparison of the preparations before you ‡ I now believe to require modification.

1. *The structure of the so-called lobe and crus.*—Accepting the common belief (as stated by Owen) that "in sharks a ventricle is continued to each rhinencephalon along its crus from the

* Part of a lecture on the brains of Plagiostomes (one of a course upon the brains of the fish-like Vertebrates, to the special students of Natural History at Cornell University) delivered May 23d, 1876.

† Notes on the American Ganoids, *Amia*, *Lepidosteus*, *Acipenser* and *Polyodon*. I. On the respiratory actions of *Amia* and *Lepidosteus*. II. On the transformations of the tail of *Lepidosteus*. III. On the transformation of the pectoral fins of *Lepidosteus*. IV. On the brains of *Amia*, *Lepidosteus*, *Acipenser* and *Polyodon*. Proc. Am. Assoc. Adv. Sci., 1875, 151–194; 3 plates.

‡ These comprised brains, entire or more or less dissected, of the following forms: *Mustelus lævis*, fœtal, young, and adult; *Acanthias vulgaris*, fœtal, and adult; *Zygæna*, fœtal, and adult; *Carcharias obscurus* (three examples); *Triakis semifasciatus*; *Odontaspis Americanus* (three examples); *Raia* (sp. ?); *Myliobatis bispinosus*; *Torpedo* (sp. ?).

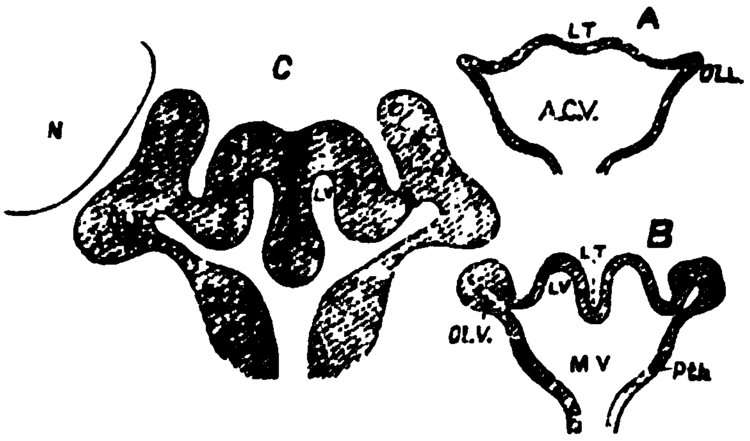
prosencephalon," I was led to conclude that the small hollow bud from the side of the anterior brain-mass (evidently the slightly modified anterior cerebral vesicle) of the fœtal *Mustelus* must elongate and expand at its tip in contact with the olfactory sack so as to form the lobe and crus; page 182. But the young and adult brains since examined show that the ventricle ends as a rounded *cul-de-sac* before reaching the "lobe." The same is the case in *Acanthias* and others with short "crura." In *Myliobatis*, *Carcharias* and others it is even more apparent that the greatly elongated crura are merely bundles of nerve *fibers*, the distal expansion of which forms the so-called lobe. Should there be found ganglionic tissue intermingled with the fibers there would be reason for closer comparison of the mass with the retina of the eye, but not, it seems to me, for regarding it as serially homologous with the optic lobe as a part of the brain. The true olfactory lobe or rhinencephalon seems therefore to embrace only the hollow base of the crus, more or less thickened and more or less distinguishable from the main mass as a conical process. The olfactory bulb, with the more or less elongated crus of many Plagiostomes, seems to be developed independently or in connection with the olfactory sack as are the general nerves. But it is very desirable to trace their formation in forms having long olfactory crura.

2. *The development and position of the hemispheres.*—If the foregoing conclusion be correct, the hemispheres of sharks and skates must be sought for elsewhere than in the thickened and hollow bases of the so-called olfactory crura. The entire anterior mass has been regarded by some as the coalesced hemispheres; and some foundation for this is afforded by the more or less distinct median furrow on its exposed surfaces. But in the adult preparations before you this furrow does not extend over the hinder part of the mass. In several its posterior termination is indicated by a vascular foramen apparently extending vertically through the brain. In the young *Mustelus* and fœtal *Acanthias* the furrow is an actual *fissure* as far back as the foramen above mentioned. The fœtal *Mustelus* presents only a shallow median depression upon the front of the anterior vesicle. Finally the horizontal sections and the dissections show the existence in some adults of the following cavities or ventricles:

A. The y-shaped remnant of the cavity of the anterior vesicle reduced by the great thickening of the walls; the posterior arm opens into the third ventricle behind; the two anterior communicate with the secondary ventricles. B. The olfactory ventricles, continued for a greater or less distance into the olfactory lobes. C. Ventricles, one on each side extending forward and usually inward within the lateral masses separated by the

furrow or fissure. D. In *Odontaspis* and some others there are posterior prolongations of the ventricle upon a higher plane than the anterior horns of the original cavity.

A fuller series of fœtal brains is required for absolute demonstration, but the appearances above described suggest the following conclusion: The hinder part of the mass corresponds to the *prothalami* of Ganoids. The true hemispheres are the lateral masses more or less completely fused on the middle line (as are the olfactory lobes of frogs and toads,) and sometimes developing at the plane of union a bundle of longitudinal commissural fibers. The hemispheres retain their typical condition as anterior protrusions of the anterior vesicle; but they lie mesiad of the olfactory lobes, and, in *Mustelus* at least, seem to be formed after them. It seems probable therefore that the commonly accepted definitions of the hemispheres and the olfactory lobes must be modified with reference to the conditions here indicated:—the latter being developed first and directly from the anterior cerebral vesicle; the former to the inner or mesial side of the olfactory lobes. Their relative positions are thus the reverse of what they are in *Petromyzon*, notwithstanding the other points of resemblance between the Plagiostomes and the Myzonts.



EXPLANATION OF FIGURES.

Figure I.—Diagrams of sections of the large median anterior brain-mass of sharks. A. From embryo *Mustelus* 37 mm. long. Horizontal section (enlarged) of the thin-walled mass which seems to be the slightly modified front and larger portion of the anterior cerebral vesicle. (In Ganoids and Teleosts this mass seems to divide above so as to form the lateral masses called by me *prothalami*). Ol.L. The commencing olfactory lobes. L.T. The center of the *lamina terminalis* or anterior wall of the vesicle. On each side the wall protrudes slightly.

B. From fœtal *Acanthias* 16 cm. long. Horizontal section, enlarged. The walls are thicker; the olfactory lobes are larger, and the lateral protrusions of the lamina terminalis are much more extensive.

C. From an adult *Mustelus*. The olfactory lobe has either expanded into or become connected with a large crescentic bulb into which the ventricle does not extend. The lateral protrusions (H) are closely united by their mesial surfaces at the suture (S). The foramen (F) marks the position of the median line of the lamina terminalis. The cavities are much reduced by the thickening of the walls.

ART. XII.—*New form of Compensating Pendulum;* by J. LAWRENCE SMITH, Louisville, Ky.

IN the construction of this new form of compensating pendulum, I have taken advantage of the very great expansibility of that combination of sulphur and caoutchouc known as vulcanite or ebonite. Its coefficient of expansion is known to approach that of mercury in the ranges of temperature from 0° to 70° C.

The mechanical arrangement adopted is a very simple one. The rod of the pendulum is of round steel, with an adjusting screw at the lower end: a round rod of vulcanite with a hole in the center is passed on to the steel rod, fitting it loosely, and being held in place by the adjusting screw. The bob of the pendulum consists of a heavy mass of brass with a hole through the center large enough to admit the vulcanite over which it passes, and by a properly arranged stop, rests on the end of the vulcanite farthest from the lower end of the pendulum, so that any expansion of the vulcanite elevates the brass bob, thus compensating for the downward expansion of the steel rod and brass bob.

There is a simple mechanical arrangement for adjusting the proper difference between the length of the vulcanite and the other parts of the pendulum.

For a second pendulum to an astronomical clock, I have used the following dimensions: diameter of the steel rod 6 mm.; diameter of vulcanite, 25 mm.; length of same, 165 mm.; diameter of brass bob, 63 mm; length of the same, 156 mm. These dimensions are in no way insisted on as being the best. For a half second pendulum I have used a steel rod 3 mm. in diameter; vulcanite 11 mm. in diameter and 63 mm. long; brass bob 38 mm. in diameter and 57 mm. long.

I have had one of these pendulums attached to an astronomical clock, and after adjustment it has been running four months with very satisfactory results. Should this form of pendulum prove itself constant and correct, it would certainly be a convenient one for transportation, and very much less costly than the ordinary form. And as for the half-second pendulum, in such constant use in mantle clocks, it will be of the greatest service and not add more than 20 cents cost to the commonest form of pendulum that can be used.

As regards the uniformity of the coefficient of expansion of all vulcanites, of course it is not to be supposed that it can be relied upon, but a very simple method is used to ascertain it for any single specimen, or for a number made of the same lot of material.

I have made experiments on several different specimens, and the results vary little from each other. The range of temperature with which the experiments were made was from zero to 43° C., on a bar 25 mm. in diameter, and 304 mm. long, this expanding in length 9–10 mm.; making the entire expansion equal to $\frac{1}{126}$ of the entire length of the rod for a temperature ranging from freezing to boiling point, giving as coefficient for linear expansion for one degree centigrade 0·000079365. This coefficient is seen to be lower than that of mercury; but from the fact that mercury corrects the pendulum by only one-half its expansion, and the vulcanite is made to correct it by its entire expansion, the length of vulcanite required is even less than the column of mercury used in the mercurial pendulum. This instrument is one whose use depends on its accuracy of operation after careful trial for some time.

ART. XIII.—*Aragonite on the surface of a meteoric iron, and a new mineral (Daubréelite) in the concretions of the interior of the same;* by J. LAWRENCE SMITH, Louisville, Ky.

I. *Incrustation of Aragonite.*

THE remarks in this communication have reference to some of the masses of iron that have been brought from that region of Mexico called the *Bolson de Mapini*, or the Mexican desert, situated in Cohahuila and Chihuahua, two of the northern provinces of Mexico; the desert being four hundred miles from east to west, and five hundred miles from north to south, bordering on the Rio Grande. This region, so prolific in masses of meteoric iron, has been described by Prof. Burckhardt of Bonn as well as by myself.

In 1854 I described three of the masses (this Journal, vol. xxviii, pp. 409); two of these have been brought to the United States, one weighing 125 kilograms and the other 630 kilograms. In 1868, eight others were brought to this country, the heaviest weighing 325 kilograms. These I described in 1869 (this Journ., Nov., 1869); and in 1871 I was enabled to give a description and an analysis of a still larger one weighing about 3500 kilograms, this last one remaining on the western boundary of the desert near El Para.

We have some account of one even larger than the last, located in the very center of the desert. So far as known there have been found in this locality not less than 15,000 kilograms of meteoric matter, an amount exceeding that which has been brought together in cabinets from all other sources.

When I examined the eight masses in 1868, I noticed a white crust on a small part of the surfaces of two of them, but at that time I could not make any critical examination of it. Within the past few months, these irons have come under my control, and therefore I have been enabled to examine the points that had been omitted, the most interesting of which forms the subject of this communication.

On one of these masses of iron, weighing 210 kilograms, there is a small amount of a white incrustation covering about 15 square centimeters of the surface: and on another, weighing 275 kilograms, there is an incrustation, which covered originally over 200 square centimeters of the surface, attached firmly to the iron, and when broken off (as most of it has been by careless handling of the mass), it brings away with it on the under surface a portion of the iron that has become oxidized: its thickness is from one to five millimeters.

It is quite hard, scratching calc spar very readily; the surface of it is irregular and granular. If broken perpendicularly to the surface of the iron and ground down, it will receive a very good polish, showing an irregular and wavy structure on many of the pieces, and parallel to the surface of the iron, with yellow and dark brown streaks like the Gibraltar limerock; it effervesces with acids, and is an incrustation of aragonite.

The following is the composition of the mineral:

Carbonate of lime	93·10
Sesquioxide of iron	1·00
Magnesia	*trace*
Insoluble residue	4·60
Water	1·00

As regards its formation, I am satisfied that the crust has been made on the iron since the fall of the latter. Conceiving this to be the case, I desired to know the nature of the rock and soil where these meteorites were found, and I have been able to gather the following particulars from Dr. Butcher who collected the specimens under examination. This spot is in an alluvial valley or plain between two ranges of high mountains running parallel with each other varying in distance from one to three miles. The mountains at the base are calcareous in formation, and in the hills and plains there are large calcareous deposits. The plain in many places is cut up with deep ravines, and several of the specimens of iron were found among the stones and sand at the bottom of the ravines, and during heavy rains were washed or covered with water. It is however only in wet seasons that the water is found remaining in the ravines and depressions of the valley, and this water is always brackish to the taste, containing a large amount of mineral matter.

Without giving any further details of the nature of this region of Mexico where these meteorites were collected, sufficient has been stated to show the probable source of the calcareous incrustation which I discovered upon two of them.

This incrustation on meteorites has been discovered but twice before, and in both instances by myself. One of them, however, is of so obscure and unsatisfactory a character that I have not given any public notice of it. The other is the case of the Newton County meteorite described by me (this Journal, II, vol. xl, 1865). It is a meteoric stone belonging to the variety classified by M. Daubrée as Syssidères; specimens of it have been furnished by me to the museums of the Garden of Plants, Great Britain and Vienna, with this incrustation in well defined particles of a translucent character adhering firmly to the surface. The entire amount of this meteorite yet known does not exceed 700 grams, although the primitive mass must still exist in a sparsely settled region of Arkansas, and when obtained will no doubt furnish specimens with a larger amount of the calcareous incrustation upon it.

2. *New Meteoric Mineral, Daubréelite.*

Two of the masses of iron above referred to have been cut across, the section made on one of them being over fifteen square decimeters; also several transverse cuts have been made. In all of these sections a number of nodular concretions have been exposed, most of them quite small, and hardly any exceeding a centimeter in diameter. At the first glance all these nodules have the appearance of very finely crystallized troilite; but a little closer inspection reveals the fact that most of these nodules have more or less of a black mineral associated with it. I had never seen anything of the kind before, it being very evident that it was not graphite. As further examination has proved it to be a new and interesting mineral, I have thought proper to designate it after M. Daubrée, who has done so much in the study and elucidation of meteoric minerals.

Daubréelite is a black lustrous mineral, highly crystalline in structure, occurring on the borders of the troilite nodules, and sometimes running across the center of them, as may be seen in one of the specimens, where, in a nodule of troilite, a vein of the mineral traverses the very center of the nodule, which is two millimeters in width and twelve millimeters long. It has a distinct cleavage, but I cannot make out its crystalline form. It is very fragile, and in the attempt to detach it from the iron, it breaks up into small fragments resembling small particles of molybdenite. It is feebly attracted in very fine particles when a strong magnet is brought in contact with it. This may arise from the presence of a minute quantity of troilite which it is

very difficult to get rid of. Pulverized, it furnishes a perfectly black powder, the smallest particle of which gives before the blowpipe a very strong reaction of chromium. Heated very intensely, it loses its brilliant color and becomes a dull black.

The powdered mineral is dissolved completely in nitric acid. The solution is intensely green, and furnishes a strong reaction of sulphuric acid and oxide of chrome. The other strong acids attack it but slightly.

This solubility in nitric acid readily distinguishes it from chrome iron. The quantity of mineral I was enabled to obtain pure, or nearly so, was very small, the reaction of the acids on the mineral being nearly the same as on troilite. I am enabled to separate them only by varying the strength of the acids, and the length of the time they are in contact with the minerals.

Less than one hundred milligrams were obtained of sufficient purity to make out its composition, and this amount furnished me 36·48 per cent of sulphur; the remainder was chrome with nearly ten per cent of iron, and a little carbonaceous matter. This mineral when obtained pure and in sufficient quantity for a thorough analysis (which I hope to make before long), will, I am satisfied, prove to be a protosulphide of chrome. The iron present being mixed with the Daubréelite. The following therefore would express its true composition: Sulphur 37 62, chrome 62·38.

This mineral is an interesting one, and is found in a very strange place, yet from what is revealed to us by the spectroscope with regard to the vapors surrounding the sun, the element chrome must be widely diffused in the matter of the universe.

ART. XIV.—*On some of the changes in the Physical Properties of Steel, produced by Tempering*; by A. S. KIMBALL, Prof. of Physics in the Worcester Institute of Industrial Science.

A FEW interesting, and, to a certain extent, novel results have recently been developed in our laboratory, which I venture to present in their present incomplete form, since the pressure of other duties will postpone, for a few months, further investigations in this direction. Up to the present time the larger number of our experiments have been made upon the behavior of tempered bars under a transverse stress, although a few qualitative trials have been made upon changes in electric conductivity and coefficients of expansion.

I. *The modulus of elasticity decreases as the hardness of the steel increases; in other words the harder the bar, the greater the deflection produced by a given weight.*

Many manuals of practical mechanics give a higher modulus for tempered than for untempered steel. Reuleaux in "Der Constructeur," (page 4,) states that it may be increased 50 per cent by hardening. Coulomb and Tredgold state that hardening has no influence whatever, while Styffe finds that the modulus is diminished. For our first experiment, five pieces of good tool-steel, each 13″ long, were cut from a half-inch square bar. These were carefully annealed, squared, and polished. No. 1 was laid aside and the others were hardened in cold water in the usual manner; No. 2 was "drawn" on a hot plate to a dark blue; No. 3 to a purple; No. 4 to a straw color; No. 5 was left hard. The modulus of elasticity was then determined by measuring the deflection produced by a weight applied at the middle of the bar. The probable error of the experiments did not exceed $\frac{1}{5}$ of one per cent. The experiment was varied in many ways, several qualities of steel and bars of different dimensions were employed with uniform results. In some grades of steel a difference of more than 10 per cent has been found between the modulus of the hardened and that of the annealed bar.

II. *The increase of deflection in a given time is greater, the harder the steel.*

It is well known that the deflection of a bar left under stress will increase for a long time. I am not aware, however, that comparative tests of the rate of increase in steel of different tempers have previously been made.

III. *The immediate set increases with the hardness of the steel.*

In the experiments each bar was of course loaded with the same weight which was allowed to act for the same number of minutes.

IV. *A bar recovers from a temporary set with greater rapidity the harder it is.*

The remarkable fluctuations in the line of the bar observed by Prof. Norton, (this Journal, April, 1876,) became more marked and had a wider range as the hardness of the bar increased. In none of the experiments referred to was a permanent set produced, though in some cases 48 hours had elapsed before the bar recovered its original line. In a few experiments an attempt was made to determine the approximate hardness of the bars by grinding. The results obtained, however, could not be considered very reliable. A more satisfactory method was found in the determination of the temperatures employed in hardening and drawing, by the specific heat of platinum, or by the use of the pyrometer.

I am indebted to Mr. F. C. Blake for the accuracy with which the experiments referred to in this note, have been conducted.

ART. XV.—*A Glass Circle for the measurement of Angles;* by LEWIS M. RUTHERFURD.

AT the summer meeting of the National Academy of Sciences, in the year 1866, I described the micrometer which I had constructed for the measurement of astronomical photographs. It was capable of measuring angles of position, and also distances in directions at right angles to each other. These last measurements were made by aid of screws arranged after the manner of those of an ordinary slide rest: these screws were constructed with great care and I had good reason to be satisfied with the smallness of their errors.

At the Spring meeting of the Academy, for the year 1870, I explained that I had been obliged to give up the idea of using screws on account of the rapid changes in their errors caused by friction and consequent wear, and I then stated that I intended to discard the screw and the compressed slide, and substitute for them a divided glass scale, to be read by a micrometer microscope, and a gravity slide with one V and one flat slide. This intention I carried out during the year, the new form being first used about the month of March, 1871. It has been constantly used since that time, and continues to give great satisfaction. The success of this divided glass scale confirmed me in a determination of long standing to try the experiment of substituting a glass circle for one of metal in some instrument for the measure of angles of precision.

Two years absence in Europe and other occupations conspired to postpone the execution of this plan until the past winter, during which it has been realized with what seems to me the most promising success. I had in my possession a spectrometer by Bruner of Paris—his small model, similar to the one used by Mascart, and figured in his paper on the measures of wave lengths. This instrument has a good steel center and was furnished with a circle divided on silver reading by means of the verniers to 10″. The diameter of the circle is small, not quite seven inches, and the inability to read smaller angles has always been its weak point. I have substituted for this metallic circle, one of glass about ten inches in diameter divided by Mr. Stackpole to ten minutes of arc, and read by two micrometer microscopes magnifying seventy-five times; each revolution of the screws being equivalent to one minute, the drums being divided into sixty parts, read to seconds with easy estimate of fractions—each degree line is numbered so as to be visible in the field of the microscope. I was able to furnish to Mr. Stackpole a well tried diamond which has made lines of the greatest delicacy, being much finer

as seen in the microscopes than the spider lines, by means of which the bisections are made. The advantages of this system are obvious, viz: perfection of surface permitting a line of any desired fineness—facility of illumination permitting the extension of the power of the reading microscopes to several hundred times—smallness of dimensions and consequent cheapness and avoidance of almost all the questions of flexure and local effects of temperature.

I am convinced from the ease with which one second is read on my instrument, with microscopes only 4¾ inches long including objectives and eye-pieces, that upon a circle of fifteen inches provided with powerful microscopes, greater precision could be attained in the reading of angles than with the largest metallic circles now in use.

For the purpose of showing the degree of precision attainable, I add two series of bisections of lines on the circle made by myself, and two made by a lady, marked respectively R. and M.

	R.	R.	M.	M.
	7″·5	1″·8	23″·6	11″·
	7 ·4	1 ·3	23 ·6	11 ·2
	7 ·7	1 ·9	23 ·3	11 ·8
	7 ·4	1 ·8	23 ·8	11 ·
	7 ·3	1 ·8	24 ·5	10 ·9
	7 ·6	1 ·8	23 ·9	11 ·5
	7 ·7	1 ·9	23 ·7	11 ·5
	7 ·4	2 ·	24 ·	11 ·5
	7 ·6	2 ·3	23 ·9	11 ·
	7 ·8	2 ·3	24 ·3	11 ·4
Mean,	7″·54	1″·89	23″·86	11″·28

It will be readily seen that the probable error of any single reading in any one of these series is considerably less than half a second, while the probable error of the mean of any series is a much smaller fraction.

New York, June 1, 1876.

ART. XVI.—*Friedrich Wilhelm August Argelander.**

FRIEDRICH WILHELM AUGUST ARGELANDER was born at Memel, in East Prussia, on the 22d March, 1799. His father, who was of Finnish descent, was a merchant of that town, whilst his mother belonged to a German family. Their circumstances were such as enabled them to give their son a very careful

* This notice is principally an abstract of that by Prof. Schönfeld in *Vierteljahrsschrift der Astronomischen Gesellschaft*, Jahrgang x, part 3, and is here cited from the "Monthly Notices" of the Astronomical Society.

training and education. Political events brought him into very early connection with historic names. After the battle of Jena the Prussian royal family left Berlin, and took up their abode for some time at Memel. The Crown Prince (afterwards King Frederick William IV.) resided at the house of Argelander's father, and formed there a strong and lasting friendship with the future Professor. Scarcely less intimate were his relations with Prince William, the present Emperor of Germany.

In due course young Argelander was sent to the gymnasium at Elbing, and in 1813 to the Collegium Fredericanum at Königsberg, from which, in April, 1817, he proceeded to the University of that town. Although from the first a diligent student, he did not show any special taste for the science in which he was to become so famous until he was attracted thereto by the lectures of Bessel. This led him to request the latter to entrust him with some calculations for the Observatory. The *Fundamenta Astronomiæ* had then been just completed; but Bessel put into his hands the reduction of the observations of 67 stars observed by himself at Königsberg, and not previously observed since Bradley, and also the determination of the latitude of the Observatory from observations of circumpolar stars. The results of these labors were published in the 5th part of the Königsberg Observations, in which he introduced our late Associate to the scientific world as "one of his most distinguished pupils." Other calculations followed, and it was not long before Argelander took part also in the observations; the first of importance being that of the occultation of the *Pleiades* on the 29th of August, 1820. Soon after that, on the 1st of October, he was regularly appointed as Bessel's assistant at the Observatory—the beginning of a career in which he enriched astronomy with results such as could only be obtained by a combination of uncommon genius with industrious zeal.

His first great labor was assisting Bessel in his survey of the heavens by zone observations from 15° south to 45° north declination, in which the whole of the microscope-readings of the circle were made by Argelander, and there is abundant evidence in Bessel's writings how highly he appreciated the care and skill with which this assistance was rendered, as well as that in the subsequent reductions. These zone observations commenced in August, 1821; earlier in that year Argelander was engaged in observations of stars at low altitude to be used in the formation of Bessel's refraction tables, and also in February and March in the observation of the Comet of 1821.

On the 1st of April, 1822, Argelander took his degree as Doctor of Philosophy, after writing a paper, *De Observationibus Astronomicis a Flamsteedio institutis.* Later in the same year

he published his able treatise, *Investigations on the Orbit of the Great Comet of* 1811, which made his name known through Europe. No other comet had been observed so extensively and over so long an interval of time; and after the most skillful and elaborate treatment of the observations, Argelander obtained an orbit of the period of 3,065·6 years (to be reduced in the next period to 2,888 years). His investigations were not without their influence upon Bessel's views on the repulsive force of comets' tails, which were further developed by him afterward in his labors on Halley's Comet and in his controversy with Encke on the resisting medium in space.

On the death of Walbeck, the position of "Observator" at the Observatory at Abo became vacant, and application was made to Bessel to recommend to the authorities at St. Petersburg one of his pupils to supply it. Though exceedingly unwilling to lose him, Bessel named Argelander, and on April 28, 1823, the latter was appointed to the vacant office, and he left Königsberg in the following month, being succeeded there by Rosenberger. His journey to Finland was also his wedding trip, he having married at Königsberg, on the 2d of May, Marie Sophie Charlotte Courtan; and with her he proceeded, through Dorpat (where he renewed his friendship, commenced in November, 1820, with W. Struve) and St. Petersburg, to his new home in the country of his paternal ancestors.

The Observatory at Abo was then newly built and indeed not in all parts quite completed. Its equipments consisted, besides smaller instruments and clocks, of a 2-foot repetition-circle, a Fraunhofer's heliometer, and especially of a very good 8-foot transit instrument by the same artist. A meridian-circle by Ertel was provided in 1825 and was not ready for use until the spring of 1827. Before that time, therefore, the observations principally consisted of comets, and casual phenomena of different kinds. When in possession of the meridian-circle, Argelander undertook a more extended course of observations; and paid special attention in particular to the stars which were known or suspected to have a large proper motion.

In the year 1828 and 1829 Argelander completed Hour XXII of the Berlin Academy Star-charts, which he had undertaken. It is one of the best of the series, and the accompanying catalogue forms one of the earliest examples of the accurate critical treatment of Bessel's and Lalande's zone observations. In the meantime great changes had occurred at Abo. On the 4th of September, 1827 a fire broke out which laid the greatest part of the town in ashes, and destroyed all the buildings, library, &c. of the University. Although the Observatory was protected by its isolated position, and lost nothing but a large

number of its impressions of printed observations, yet it was ultimately resolved to remove it as well as the University to the new capital at Helsingfors. Argelander was named Professor of Astronomy at the newly founded University there, and a new Observatory was ordered to be erected by the architect Engel, who had already built that at Abo. The plan was approved in 1830; but difficulties were found in laying the foundation on account of the nature of the soil. Finland was also visited about this time by the cholera, which travelled over Europe; and Argelander took an opportunity, after leaving Abo, of revisiting his old home in Prussia, and renewing his personal intercourse with Bessel. In August, 1832 he took up his abode at Helsingfors, though the building of the Observatory was not yet finished. Observations commenced there in the following year; and in November, 1834 the meridian-circle was ready for use, the new observatory being also provided with a Munich refracter of 9 ft. focal length and 6½-in. aperture, observations with which commenced in September, 1835.

Argelander devoted himself principally to an extensive series of observations of the brighter circumpolar stars, and to an accurate investigation of his circle, especially of its flexure, by observation of stars and their reflected images. It was whilst at Helsingfors that he printed the Abo observations and catalogue, as well as his well-known treatise on the motion of the solar system deduced from his own observations of 390 stars, with results nearly similar to that formerly obtained by Sir William Herschel.

His stay at Helsingfors was not of long duration. The Prussian Government had resolved in 1836 to establish an astronomical institution at Bonn, on the Rhine. In August of that year the Directorship of the Observatory was offered to Argelander; and early in 1837 he took up his residence in Bonn, and energetically commenced the ordering of the instruments and the preparations for the building of the Observatory. As a temporary *locale* in the meantime for observations, he selected a bastion of an ancient fortress close to the Rhine, where he carried on for some years his astronomical work with such means as he had—latitude determinations, comet observations, &c. He also made excellent use of his involuntary leisure in the formation of his "New Uranometry," or determination of the relative apparent magnitudes of all the stars visible to the naked eye in Central Europe by direct comparison in the sky, as well as in the connected subject of the changes of magnitude of the variable stars. To the latter he continued to give a great deal of attention afterwards, especially in regard to those interesting stars, *Algol* and *S. Cancri.*

Impatient at the slow progress of the Observatory (as he considered it) Argelander had a small temporary building erected, in which he could use (close to his Rhenish bastion) a 5-foot transit instrument by Ertel, of 4 inches aperture. Having provided this with a sector to determine differences of declination, he commenced extending Bessel's zone observations further to the north, from 45° to 80° declination. Thus he made 26,424 observations of very nearly 22,000 stars; which, begun in May, 1841, were essentially completed, with the aid of an assistant, in June, 1843, some gaps being filled up in the subsequent spring.

At last, in the year 1845, the new Observatory was in a position to be used. Its principal instruments were a 3-foot meridian-circle by Pistor, with telescope of 6-foot focal length, and a heliometer by Merz. For some years cometary observations (a large number of which bodies appeared about that time) and observations of the small planets—the long series of discoveries of which had then just commenced—occupied much of the time of the establishment. But in 1849 Argelander began a new series of zone observations of stars, this time going south from Bessel's limit, or from 15° to 31° south declination. Thus, by May, 1852 he had made, in 200 zones, 23,250 observations of more than 17,000 stars. Every precaution was taken by comparison and by observation of known stars to secure the greatest accuracy possible for the results.

But even before the completion of these southern zones, Argelander had formed a plan for a much greater work to extend the knowledge of the starry heavens. Bessel had before conceived the idea of determining the places of all stars down to the ninth magnitude, but had abandoned it for the scheme of the Berlin Academy Star-Charts, which, however, after the lapse of a quarter of a century, were unfinished, and, moreover, they embraced only a limited zone.

Early in 1852, therefore, Argelander resolved to commence that great *Durchmusterung*, or survey of all the stars of the northern hemisphere down to the ninth magnitude, and including a large number somewhat fainter than that, with which his name will be for ever associated. The whole number of stars recorded in these zones, between the north pole and 2° south declination, amounting to 324,198, and this gigantic labor, including the laying down of the charts and publication both of them and of the catalogues occupied Argelander and his assistants until the year 1863. They are too well known to astronomers to make any discussion of them necessary here. In the seventh volume of the *Bonn Observations*, published in 1869, are some interesting investigations into the proper

motions of 250 stars, which Argelander was led into by comparison of observations.

He always kept in view the desirability of obtaining accurate meridional observations of all stars down to the ninth magnitude, whose approximate positions are contained in the *Durchmusterung*. It was necessary, if this could be done, that the labor should be shared by different Observatories, and be prosecuted on a uniform system. Thus would a basis be afforded for a much larger number of accurate determinations and observations of every kind. In the year 1867 Argelander laid his plan before the German Astronomical Society, which was afterwards adopted, with trifling modifications. The Bonn Observatory was to undertake one zone of 10° in breadth of declination; but Argelander, now approaching his seventieth year, entrusted the details of the execution to his assistants, engaging himself in labors of smaller compass, such as investigations of stellar proper motion.

Argelander always took a lively interest in the progress of science generally, and also in the affairs of the University of Bonn, of which he was twice elected Rector. Many of the scientific societies of Europe and America made him one of their corresponding or honorary members, and he was chosen an Associate of our own on the 14th of January, 1831, being also our medallist in the year 1863.

Until the summer of 1874 he had always enjoyed excellent health; but in August of that year he was attacked by a fever of the typhus kind, which visited the neighborhood about that time. In the autumn he rallied, and was able to resume some of his labors. But the appearance of recovery was delusive; his strength failed more and more, and, retaining his interest in science almost to the last, a tranquil death early in the morning of February 17, 1875, terminated a life which had been so useful to astronomy. His wife (with whom he had been affectionately united for nearly fifty-two years), two sons, and one daughter, married to Professor Krüger, survive him.

W. T. L.

Art. XVII.—*On Dinitroparadibrombenzols and their Derivatives*; by Peter Townsend Austen. First Paper.

Two kilograms of pure crystallized solid (para) dibrombenzol were divided into portions of 250 grams, and each portion added to a mixture of 800 grams of fuming nitric acid and an equal volume of concentrated sulphuric acid, and then heated on a sand bath, when a violent action set in, during which it was found advisable to remove the burners. A red-

dish yellow oil settled in the bottom of the flask. After boiling three hours the mixture was allowed to cool, and then poured in a thin stream into a large excess of cold water. The oil sank to the bottom and gradually solidified, an operation which may be greatly accelerated by vigorous stirring with a glass rod. The nitrired product from 500 grams of the dibrombenzol after the washing out the acid with water, was dissolved in about a kilogram of glacial acetic acid, filtered, and allowed to stand about seventy hours. A copious separation of the first (α) dinitroparadibrombenzol, containing a considerable amount of the second (β) isomere and but a small amount of the third (γ), took place. By repeated crystallization, first from carbon disulphide and then from glacial acetic acid, it was obtained perfectly pure. The acetic acid filtrate from the first separation contained the β- and γ-isomeres and some of the α. The solution was treated with a large excess of water, and the substances in solution were thus precipitated in the form of a yellow oil, which was then separated from the water by means of a stop-cock-funnel, heated on a water-bath until it was entirely dry, dissolved in about 1¼ kilos. of carbon disulphide, and allowed to stand By standing, a small separation of impure α-isomere generally occurs. The carbon disulphide was then distilled off in portions of 200 c. c., and the respective crystallizations, which consisted of the β-isomere containing a good deal of the α-isomere and traces of the γ, collected. When no more separated the thick oil was heated on a water-bath until the carbon disulphide was entirely volatilized, after which it was exposed to a temperature of 5° for three days, when it became solid. The mass was carefully rubbed in a mortar with ether, at the same temperature, and this ethereal extract (consisting of much γ and little β) separated by a filter-pump. The ether was then evaporated, the oil again exposed to the same temperature, and the operation repeated until the substance dissolved in the ether without leaving a residue. The oil was then exposed to a temperature of about −8° to −10°, for nearly two weeks, during which small amounts of the β-isomeres crystallized out and were separated by filtering the oil directly with the filter-pump. Finally no more separated from the oil, which then appeared to contain only an exceedingly small amount of the β-isomere.

Alphadinitroparadibrombenzol.

The alphadinitroparadibrombenzol containing traces of the β-isomere crystallizes from glacial acetic acid in beautiful striated transparent needles, often attaining a length of 25 cm. and a diameter of 3 mm. When perfectly pure, however, it crystallizes from the same solvent, in short, compact, white,

glittering needles, or small prisms. From carbon disulphide it separates in the form of small, hard, white crystals. The compound is insoluble in water, easily soluble in boiling absolute alcohol and glacial acetic acid, as well as in benzol, and acetic ether. It is slightly volatile in steam. Fuses at 159° to a transparent slightly yellow liquid.

0·3034 grm. substance gave 0·0190 H^2O and 0·2452 CO^2.
0·1749 grm. substance after the method of Carius gave 0·1998 AgBr and 0·0027 Ag.

Calculated for $C^6H^2(NO^2)^2Br^2$.	Found. I.	Found. II.
C = 22·08	22·04	....
H = 0·61	0·69	....
Br = 49·08	...	49·74

Nitroparadibromaniline.

In a preliminary notice* I mentioned that α dinitroparadibrombenzol by treatment with ammonia formed a dinitrobromaniline, which under the influence of amylnitrite gave a dinitromonobrombenzol. By repetition of the experiments, however, with much larger amounts and perfectly pure substances, I find that the reaction is different.

By treating the α-dinitroparadibrombenzol with strong alcoholic ammonia the crystals take on a light straw yellow color. By heating in a closed tube at 100° for three hours the reaction is completed. The red solution obtained was precipitated with water and the resulting yellow precipitate crystallized from dilute alcohol. The filtrate from the precipitate produced by water gave no trace of bromine with silver nitrate, but starch and potassium iodide proved the presence of a considerable amount of nitrous acid.

By repeated crystallizations from alcohol the substance was obtained pure. It forms orange, yellow, and red needles, which fuse at 75°, and are quite volatile with steam. It is very soluble in most solvents, with the exception of water in which it dissolves with difficulty.

0·28 grm. substance, third crystallization, gave 0·0426H^2O and 0·2536 CO^2.

0·2092 grm. substance, fifth crystallization, gave, after the method of Carius, 0·2644 grm. AgBr and 0·0008 Ag.

Calculated for $C^6H^2Br^2(NO^2).NH^2$.	Found. I.	Found. II.
C = 24·32	24·69	....
H = 1·01	1·65	....
Br = 54·05	....	54·06

* Ber. d. d. chem. Ges., viii, 1183.

Amyl nitrite acts at ordinary temperatures on the nitroparadibromaniline and forms, not as I formerly supposed, a dinitromonobrombenzol, but the ordinary mononitroparadibrombenzol. All the properties of the nitrodibrombenzol (fusing point 84°) obtained in this manner agreed perfectly with those of the well-known mononitroparadibrombenzol.

This, as far as I know, is the first case in which the nitroxyl of a nitro-haloid-benzol is substituted by the amido-group in preference to the haloid atom. In the first series there is among others the well-known formation of guanidine from nitrochloroform by action of ammonia, effected by Hofmann.*

It seemed extremely improbable that aniline could act in a satisfactory manner on the alphadinitroparadibrombenzol, since the disengaged nitro-group would, without doubt, exert a decomposing influence on the aniline itself as well as on the new compound formed. The dinitrodibrombenzol was treated with an excess of aniline, and the mixture boiled. A strong reaction, attended with a characteristic deep red color, occurred. Chlorhydric acid precipitated an oil, and, by stirring, brown flocks were obtained. The product was soluble in alcohol with a deep red color, but separated from the solution as a slimy mass from which no product susceptible of analysis could be obtained.

By the action of natriumhydrate solution on the alphadinitroparadibrombenzol, I have obtained a substance forming red salts, which I take to be a nitrobromphenol, and concerning which I shall, at the earliest opportunity, give full particulars.

Royal Laboratory of Berlin, April 16th, 1876.

ART. XVIII.—*On a New Formation of Dinitroaniline, and some Reactions of Dinitrobrombenzol;* by PETER TOWNSEND AUSTEN.

ENGAGED in an extensive research concerning the stability of the bromine atom in dinitromonobrombenzol, I was led to treat that compound with potassium cyanate in the hope of obtaining a dinitrophenylcyanic ester, according to the reaction,

$$C^6H^3(NO^2)^2Br + KNCO = C^6H^3(NO^2)^2NCO + KBr.$$

Dinitrobrombenzol was mixed with about one and a half times its volume of potassium cyanate, and the mixture heated to 100° in a closed tube with very dilute alcohol for eight hours; on cooling, the tube became filled with a mass of bright yellow leaflets, and on opening gave off carbonic acid. The

* Ann. Chem. Pharm., cxxxix, 107.

substance, after crystallization from boiling water, fused at 175°–176°, and on analysis* proved to be the ordinary dinitroaniline.

The reaction by which dinitroaniline is formed admits of various explanations. Wöhler has shown that potassium cyanate by repeated distillation with water, splits according to the formula—

$$2KNCO+4H^2O=CO^3(NH^4)^2+CO^3K^2.$$

Hence we may suppose the formation of the dinitroaniline to be due simply to the action of the dinitrobrombenzol on the ammonium carbonate,

$$CO^3(NH^4)^2+2C^6H^3(NO^2)^2Br=2C^6H^3(NO^2)^2NH^2+CO^2+H^2O+2HBr.$$

The bromhydric acid thus formed acts on the potassium carbonate, so that the whole reaction is—

$$2CONK+2C^6H^3(NO^2)^2Br+4H^2O=2C^6H^3(NO^2)^2NH^2+2CO^2+2KBr+2H^2O.$$

We can, however, suppose the action to take place directly without admitting the previous formation of ammonium carbonate—

$$C^6H^3(NO^2)^2Br+KNCO+H^2O=C^6H^3(NO^2)^2NH^2+KBr+CO^2.$$

Nor is there anything very improbable in the supposition that ammonium carbonate is not formed previously, as there are so many cases in which a substance withdraws from another elements not previously directly united with each other, but with which it can form a compound (predisposing affinity).

It is, however, also not impossible that the formation of the dinitroaniline may depend upon the production and subsequent decomposition of a dinitrophenylcyanic ester according to the reaction discovered by Wurtz,

$$\begin{array}{r|c|} C^6H^3(NO^2)^2N & CO \\ H^2 & O \\ \hline \end{array}$$

but this appears to me doubtful, since the dinitrobrombenzol is not freely soluble in the very dilute alcohol used. Hence the potassium cyanate is exposed principally to the action of the water, and much less to the action of the dinitrobrombenzol; therefore, although a partial formation of the ester might take place, the chief part of the potassium cyanate would be decomposed at the same time by the action of the water, so that if the ester were formed, it could only be in small quantities.

* Calculated.	Found.
C = 39·34	39·35
H = 2·72	3·01

Mononitrobrombenzol and Potassium Cyanate.

The substances, heated in a sealed tube to 100° with dilute alcohol for eight hours, gave no mononitroaniline, as was to be expected, since mononitrobrombenzol is not acted on by ammonia itself under 160°. The cyanate, however, was completely converted into the corresponding carbonates.

Trinitrochlorbenzol and Potassium Cyanate.

By boiling a concentrated solution of potassium cyanate with trinitrochlorbenzol, I obtained, with strong evolution of ammonia, a red oil which solidified on cooling, and contained considerable unchanged trinitrochlorbenzol. The filtrate contained chlorine (showing that a reaction had taken place), and some picric acid, while chlorhydric acid precipitated a green powder. I have not as yet had time to examine either of these substances farther than to establish the absence of trinitroaniline. By heating for five hours at 100° no picramide was obtained.

Dinitrobrombenzol and Water.

Gottlieb* has stated that trinitrochlorbenzol was decomposed in the cold by water. It was afterwards found by Clemm† that this was not the case, trinitrochlorbenzol not being acted on by water even when boiling. Later, however, Engelhardt and Latschinoff‡ found it was acted on by boiling water.

With dinitrobrombenzol I found no action on boiling with water. The substance was then heated with water in closed tubes successively at 100°, 150°, and 200°, for eight hours, in all these tubes there was no pressure or formation of bromhydric acid. At 220° a minute trace of bromhydric acid had formed, and the liquid was perceptibly reddened on addition of sodium hydrate solution. After heating at this temperature the substance remained liquid for several days, although when it had solidified, it was found to have lost none of its characteristic properties.

Dinitrobrombenzol and Potassium Nitrite.

It appeared not impossible from the ease with which the bromine atom in dinitrobrombenzol can be substituted (although this is chiefly the case in substitution by a positive radical), that by action of potassium nitrite a trinitrobenzol might be formed. The substances were heated in a closed tube six hours with dilute alcohol at 100°. The tube on cooling contained massive red needles of potassium dinitrophenylate. Much aldehyde had also formed. The reaction had probably been—

* Ann. Chem. Pharm., xcii, 326. † Journ. fr. pr. Chem., [2], i, 145.
‡ Zeit. Chem., 1870, 235.

$$C^6H^3(NO^2)^2Br+2KNO^2=C^6H^3(NO^2)^2OK+KBr+(N^2O^3\,?)$$

The resulting nitrogen oxide, or oxides, had acted on the alcohol and produced aldehyde. Sealed under the same conditions with 99 per cent alcohol, there was but an exceedingly slight reaction, only traces of the phenol having been formed, which doubtless owed their origin to the small amount of water present. The same results were obtained with sodium nitrite. I shall describe the application of this method of phenol formation to other compounds at another opportunity.

Dinitrobrombenzol, Benzol, and Zinc.

Since benzylchloride treated with benzol and zinc dust gives a benzylbenzol, it seemed not improbable that dinitrobrombenzol might give a dinitrodiphenyl, owing to the weakened attraction of the bromine atom from the presence of the nitro-group, although in this case the bromine atom is attached directly to the benzol skeleton, and not indirectly, as in the benzylchloride.

Dinitrobrombenzol, benzol, and zinc dust were heated twelve hours in a closed tube at 100°, and then again at 160°. In both cases there was no action. Toluol instead of benzol also remained unchanged. Perhaps nitro toluol, in which the hydrogen atom of the methyl-group may be weakened by the introduction of the nitro-group in the benzol kernel, may give better results.

Dinitrobrombenzol and Sodium Acetate.

Wishing to ascertain if a dinitrophenyl acetic ester could be obtained according the reaction

$$C^6H^3(NO^2)^2Br,+CH^3COONa=CH^3COOC^6H^3(NO^2)^2+NaBr,$$

I heated the substances with alcohol for six hours in a closed tube at 100°. There was no pressure on opening the tube, but a strong smell of acetic ether. The tube contained orange-red crystals of sodium dinitrophenylate, and in the solution there was considerable sodium bromide. The reaction had probably gone.

$$\text{I.}\quad \begin{array}{r} C^6H^3(NO^2)^2\boxed{BrNa}O.OC.CH^3 \\ C^2H^5\boxed{OH} \end{array} = \left\{\begin{array}{l} C^6H^3(NO^2)^2OH \\ CH^3COOC^2H^5 \\ NaBr. \end{array}\right.$$

$$\text{II.}\quad \begin{array}{r} C^6H^3(NO^2)^2O\boxed{H} \\ CN^3.COO\boxed{Na} \end{array} = \left\{\begin{array}{l} C^6H^3(NO^2)^2ONa \\ CH^3.COOH. \end{array}\right.$$

$$\text{III.}\quad \begin{array}{r} CH^3.COO\boxed{H} \\ C^2H^5\boxed{OH} \end{array} = \left\{\begin{array}{l} CH^3.COOC^2H^5 \\ H^2O. \end{array}\right.$$

So that the whole reaction would be—

$$C^6H^3(NO^2)^2Br+2CH^3.COONa+2C^2H^5OH=C^6H^3(NO^2)^2ONa+NaBr+H^2O+2CH^3COOC^2H^5.$$

The next time, to avoid the formation of acetic ether, the substances were heated with glacial acetic acid at 160°. The whole product was sodium dinitrophenylate. Hence probably,

$$\begin{array}{l} C^6H^3(NO^2)^2|Br.| \\ |CH^3.COO|Na| \\ |CH^3.CO|ONa| \end{array} = \left\{\begin{array}{l} C^6H^3(NO^2)^2ONa \\ (C^2H^3O)^2O \\ NaBr, \end{array}\right.$$

although at the time I neglected to prove the formation of the acetic anhydride. The substances heated, under the same conditions with acetic anhydride, remained entirely unchanged.

We see hence that although the stability of the bromine atom is greatly weakened by the introduction of nitro-groups, this weakening is to a great extent only in relation to positive radicals. Thus dinitrobrombenzol reacts easily with ammonia, but with potassium nitrite or sodium acetate there is no analogous reaction. By inversion it naturally follows that in aniline the amido-group must be rendered much more stable by the introduction of nitro-groups. This is shown to be so by the fact that while aniline is most violently acted on by amylnitrite, trinitroaniline remains, under the same treatment, utterly unaffected.

ART. XIX.—*On Southern New England during the melting of the Great Glacier;** by JAMES D. DANA.

APPENDIX: *On the discharge of the flooded Mill River into the Quinnipiac, and the effects as registered in the drift deposits of the New Haven plain.*

IN my memoir on "Southern New England during the melting of the great Glacier," I reached the conclusion† that, during the Champlain period, or that which opened with the melting of the ice, the southern coast of New England, along Long Island Sound, was submerged below its present level not more than fifteen feet, and perhaps less than ten. It was announced,‡ as a consequence of this fact, that the high terraces of stratified drift about the heads of the estuaries and along the river valleys could not have been made by salt water, and must have been due to the freshwaters of the enormously

* The former parts of this memoir are contained in this Journal, III, x, 168, 280, 353, 409, 497, and xi, 178.

† Ibid., x, 434. ‡ Ibid., x, 435.

flooded streams; and that all the drift-deposits of the New Haven region, now thirty to fifty feet above mean tide, were included in the freshwater formations—the saltwater beds being confined to the coast.

The New Haven deposits had been described* as having, to a great extent, a cross-laminated structure, with the oblique lamination dipping for the most part seaward; and hence it was evident—contrary to what I had once supposed—that this dip corresponded in direction with the flow, both being seaward. My former conclusion on this point was based on the view that the New Haven estuary beds were marine in origin; and this appeared to be sustained by the fact† that in the stratified drift beds at the mouth of the Quinnipiac Valley (or where the valley expands into the New Haven plain, west of C on the map, p. 415 of vol. x), the *upper* stratum, twenty feet thick, had the cross-lamination dipping landward, and the *underlying* stratum seaward; for the change of current indicated by this local change of dip seemed to be accounted for by supposing the lower stratum to have been made by the incoming tide, and the upper by the outflowing stream when the flood was at its height. I closed my memoir by rejecting this explanation of the change of current, but without offering any other in its place.

My object at this time is to give another explanation; and to show that while the Quinnipiac waters deposited the lower stratum, the upper was formed by a discharge of Mill River into the Quinnipiac over the place where the unlike strata occur.

As has been explained (and is illustrated on the map, page 415 of volume x), Mill River and the Quinnipiac are parallel streams, joining their waters at the head of New Haven Bay. For the last nine miles of their courses they are less than three miles apart; and the low dividing ridge (Quinnipiac Ridge of the map) terminates near New Haven in the short trap and sandstone ridge called East Rock (E, on the map). Below this termination no barrier intervenes excepting a plain of drift deposits, and here is the place where the upper stratum of twenty feet has the reversed cross-bedding. Now if it can be shown that Mill River was throughout its course a violent cataract, flowing at a level far above that of the Quinnipiac, while the Quinnipiac for the last six miles had almost no descent, and was in this part more like a lake or basin than a river, it will be plain that Mill River, on clearing the south extremity of the East Rock ridge, would have rushed around the point, toward the Quinnipiac.

The facts sustaining this view have already been stated in

* Ibid., x, 191. † Ibid., x, 173.

my former papers.* At North Haven, or six miles north of New Haven, the Quinnipiac River is now on a level with the ocean, while Mill River in the same latitude is sixty feet above it. The valley-terrace of stratified drift is, in each valley, about forty-five feet in height above the stream. Consequently, in the Champlain period the descent, from that point to Long Island Sound, of Mill River was 105 feet, and of the Quinnipiac, only forty-five feet. Moreover, the Quinnipiac terrace has nearly the same height at North Haven and five miles south; so that the waters over this broad area during the Champlain flood were nearly those of a great basin. But, abreast of this long Quinnipiac basin, the Mill River torrent was dashing on with a pitch of ten feet a mile. And it continued this rapid plunging course along its shallow valley until it had passed East Rock, where the valley terrace is seven feet higher than that of the Quinnipiac adjoining. It is therefore manifest that, on reaching the southern extremity of the ridge separating the two valleys, it would have made a quick turn around the promontory and plunged into the Quinnipiac basin; and this would have carried it northeastward directly over the place where the evidences of reversed currents occur in the drift deposits. This place of discharge would not have taken off all the Mill River waters, or the larger part; for the water level there, when the flood was at its height, was still thirty to thirty-five feet above the sea-level—height enough to have kept the tumultuous waters mainly on a seaward course.

We hence learn from the drift deposits at this place of junction of the two streams, southeast of East Rock, (a mile north of the present head of New Haven Bay and six miles from its eastern cape), the following facts:

1. Until the waters of the flooded streams had reached, at the place mentioned, a height of fifteen feet above the then-existing sea-level, neither stream overbalanced the other: for the deposits of the lower stratum within the range of the Quinnipiac valley show, by their structure, that they were made by the flow of Quinnipiac waters. The pitch of the waters to the Sound was then but two or two and a half feet a mile.

2. Until the same water-level was reached, the flow—though rapid and plunging, as proved by the flow-and-plunge structure of the beds—was quiet compared with what followed; for this lower stratum consists mainly of sand and fine pebbles.

3. The increase in the flood on passing that level was sudden, as if the dissolution of the glacier had then received greatly accelerated progress. For the transition in the bedding, and in the color of the sands, is abrupt, with no fine layer between to indicate an epoch of repose; and, moreover, the *upper* stratum is

* Ibid., x, 413.

very much the coarsest; along Mill River valley, it is to a great extent, in contrast with the stratum it overlies, a cobble stone deposit, and this evidence of hurrying waters continues along its course through the New Haven plain for a mile and a half to the Bay.* Further, the height of the deposits where the stones are coarsest is ten feet below the normal height, because in the dashing flood, the finer material was drifted off.

4. The flow from Mill River into the Quinnipiac basin diminished in velocity as the waters spread in that direction. For, while the upper stratum adjoining Mill River on the east is a mass of coarse pebbles, too stony to show any cross-bedding, going farther eastward, toward the Quinnipiac, the stony character diminishes, and finally, in the course of three-fourths of a mile, the beds consist largely of sand.

5. The great plain of stratified drift, southeast of East Rock, forty to forty-three feet in height above the sea-level, which bounds the Quinnipiac salt meadows on the south and pushes the river against the eastern hills, was made largely of sands contributed by the Mill River torrent.

6. The Quinnipiac waters added little to the height of this drift-deposit plain or terrace: for the upper stratum bears evidence of Mill River action nearly or quite to its top. There are over the top some areas of whitish sand, one to three or four feet thick; and a bank of such sand, finely and evenly bedded, lies, unconformably against the slope of stratified drift facing the Quinnipiac basin; † and these may be formations from the Quinnipiac waters after the Mill River floods had subsided.

7. Mill River—now not over fifteen miles in length—is an example of a little stream that was a great river during the Glacial flood. It owes this partly to its having been one of the water-courses that aided, as I have pointed out,‡ in discharging the flooded Connecticut—the overflow at Northampton and Westfield giving a vast supply of waters to the Farmington Valley, enough to fill the wide valley over a hundred feet in depth, and forcing them to find a discharge into Long Island Sound by the Quinnipiac and Mill Rivers. It was probably through this supply of waters from the Connecticut that the floods of Mill River were prolonged until the drift deposits of the New Haven plain had reached their extreme height.

* Ibid., x, 175.

† Ibid., x, 179, 180, where a figure is given. The origin of these beds is otherwise explained at that place, the error that the estuary beds were marine, coloring much of the reasoning in that first paper on "Southern New England."

‡ Ibid., x, 506.

ART. XX.—*The Greenstones of New Hampshire and their organic remains;* by GEO. W. HAWES. With plate V.

THE occurrence in Eastern North America of rocks pertaining to what is appropriately styled the "greenstone" series has been noticed by different observers. In a report upon the geology of the Connecticut Valley, Professor Edward Hitchcock distinguished these from all the other rocks, by the name of "chloritic and talcose schists."* Dr. T. Sterry Hunt, in the Geology of Canada, has given analyses and descriptions of greenstones, and has discussed their mode of formation. Professor C. H. Hitchcock has noticed these rocks in New Hampshire, and has carefully studied their extent and distribution.† The "chloritic formation" near New Haven, which was noticed at length by Percival, has been recently determined by Professor J. D. Dana to consist of greenstones, and its relationship to the surrounding formations has been by him pointed out.‡ In the present article it is proposed to describe some of the more important members of this group occurring in New Hampshire, and, from the evidence afforded by chemical and microscopic study, to attempt to show their origin and mode of formation. These studies have been prosecuted under the direction of the Geological Survey of New Hampshire, at the head of which is Professor C. H. Hitchcock, and with his aid it is proposed to prepare a treatise, as complete as possible, upon the rocks of the State, which will form a part of the third volume of his report.

These greenstones, as described by Professor Hitchcock, cover a large area in the northern part of the State, and extend southward over a long irregular strip of territory which follows the course of the Connecticut Valley. They are referred by him to the Huronian age. The rocks of the whole formation are very generally green, and there is a remarkable constancy in their mineral and chemical composition, owing doubtless to the constancy of the conditions under which the beds were originally accumulated. There is sufficient diversity in these rocks, both in physical and chemical properties, to allow the best of evidence to be obtained in the field, showing that they are all metamorphosed sedimentary accumulations, instead of igneous in origin, as too generally claimed for rocks of this class. They are interstratified with one another in various ways, and are far from appearing as a result of violent eruptions,

* This Journal, I, vi, 26.

† This Journal, III, vii, 468 and 557, also vol. i, Geology of New Hampshire, p. 532.

‡ This Journal, III, xi, 119.

they were accumulated in quiet waters and consolidated under very gentle influences.

As in the vicinity of New Haven—where the rocks have been shown to be of undoubted metamorphic origin—many kinds are found which so closely resemble true trap rocks, that it is well nigh impossible to distinguish them in hand specimens; and, as will be seen beyond—there are cases where even the most careful microscopic study is inconclusive. Although only extended observations made in the field can decide whether the rocks are truly stratified or intrusive, yet it is believed that some characters are given in the descriptions beyond which will be of service in their classification.

The old name "greenstone" is a good general term to apply to the whole group, because the prevailing color of the rocks is green; indeed it is so common that the formation has always been colored green upon the geological maps; and the term "greenstone" has now become so wide in its meaning that it may well embrace all the rocks of the formation. It is intended to include under the term, all basic metamorphic rocks whose prominent coloring ingredient is either hornblende, pyroxene or chlorite. There are green acidic rocks in the formation, but they do not sufficiently resemble the rest to need to come under a common term. The true greenstones are all so much alike in physical appearance that if the term is restricted as proposed it will be found of much convenience in use.

In this formation there are many varieties of all the rocks spoken of in this article. It is proposed here to describe these variations in but general terms, but in the third volume of the Geology of New Hampshire, the rocks will be more minutely described, additional figures will be given, together with the results of the study of the other rocks found with these, but which are not greenstones if we restrict that term as proposed.

1. *Metamorphic Dioryte.*—The most prominent member of this group of greenstones is metamorphic dioryte, or *metadioryte*, and it includes both oligoclase-dioryte and labradorite-dioryte; varieties which in the region cannot be distinguished without a chemical analysis. This rock is very variable in its texture in different localities, sometimes being so coarse as to enable one to separate the crystals mechanically, and observe the cleavages of the minerals; sometimes being very compact, and well nigh impossible to distinguish from doleryte. The hornblende gives a dark color to the rock, and by this property it is easily distinguished from the light green chloritic rocks. The feldspar is not easy to determine; but an examination of its optical properties shows it to be triclinic. Whether it be oligoclase or labradorite is not a matter of great importance, since a very slight variation in the composition of the sediments would produce a change in the species.

The microscope furnishes as conclusive proof as the stratigraphy that these diorytes are metamorphic. Often in these basic rocks free quartz is associated with feldspars low in silica; and in Stewartstown there is a dioryte in which carbonate of lime is associated with a triclinic feldspar, and also free quartz. Such circumstances as these are easily understood, if these rocks were consolidated under very gentle metamorphic influences, but would not be expected in a rock which had been once in a condition of igneous fusion except as a result of alteration. It seems as if the mass had been under such conditions of heat and pressure as to give action to chemical affinities, but only within a very narrow range; so that crystals of different minerals might be formed from *fine* mud, while a larger grain of sand would be left unaffected. The conditions of metamorphism were such that they gave full scope to chemical affinity, only where the original deposits were impalpable in texture.

These diorytes vary much in their mineral composition. At Littleton some are very feldspathic, with large crystals of labradorite, making a porphyritic dioryte. At North Lisbon some specimens are very hornblendic, and large crystals of hornblende are developed in the finer ground-mass. At Lancaster they are very micaceous, and there are everywhere coarse-grained and fine-grained varieties. Fig. 1, plate IV. is intended to illustrate the appearance of the minerals of these diorytes under the microscope with ordinary transmitted light. It is drawn from a thin section of the North Lisbon rock, and is magnified 35 diameters. It shows the color of the hornblende, which, while dark in the mass, is very prettily green when made so thin. The hornblende is generally fibrous, and is found in large crystals, yet microscopic crystals are always scattered through the feldspar, as shown. The mica is biotite and very dichroic, becoming nearly black with a quarter revolution of one nicol. A round grain of quartz is seen in the middle of the feldspar, and the feldspar when placed between the nicol prisms is found to be triclinic.

To the chemical variations reference has already been made. To serve as a basis for calculation, the hornblende contained in a dioryte from North Lisbon was analyzed. In it the hornblende in places had crystallized out in large orbicular masses half an inch in diameter. It appears under the microscope in color and structure like the large crystal in the section figured. The crystals are fringed on the edges, and consequently on the outside are intimately mixed with feldspar; but in the middle they are pure, as was proved with the microscope. A portion of the hornblende free from associated ingredients was analyzed with the following results:

Silica	49·03
Alumina	13·72
Ferrous oxide	9·84
Manganous oxide	·40
Lime	11·22
Magnesia	11·96
Soda	2·40
Water (ignition)	·90
	99·47

This analysis shows that these diorytes have a highly aluminous hornblende, resembling in all respects some kinds of the variety called pargasite. I would refer to the analyses published upon page 238 of the fifth edition of Dana's Mineralogy. That hornblende can thus take into its composition so much alumina and alkali shows under what varying conditions of composition this mineral may be formed. An analysis of the rock from North Lisbon gave 51·25 per cent of silica, while another containing the same variety of hornblende gave 55·62 per cent. In the former the feldspar is labradorite, and the amount of silica in the latter seems to imply that it is probably part or all oligoclase.

In some places the dioryte develops a well defined schistose structure, and thus becomes *diorytic schist.* The microscope is unable to detect a great difference in composition; it only indicates a more finely fibrous and more diffused hornblende, less feldspar, and more grains of quartz. This rock is very common at Cornish. By further addition of quartz and diminution of the feldspar this rock graduates into hornblende schist.

2. *Metamorphic Diabase.*—Hydrous rocks are very common in this region, in which chlorite is a prominent ingredient. They generally contain pyroxene and sometimes hornblende. These rocks like the hornblendic are both massive and schistose. The massive rocks, having labradorite in addition to the minerals above enumerated, are *metadiabase.* They are very extensively developed in the extreme north, but are common as far south as Hanover. They are often quite complex in structure, but, as in the case of igneous diabase,* the chlorite imparts to the rock a light green color which makes it easily distinguishable from the diorytes. In plate V, figure 2, the microscopic structure of this rock is represented. The figure is drawn from a section of a specimen from Littleton, and is magnified 35 diameters. The chlorite in these rocks has usually an amorphous appearance, occurring, as shown in the figure, in irregular masses, with little appearance of structure; yet, as it exhibits bright colors between crossed nicols, it is all

* This Journal, vol. ix, March, 1875.

crystalline. The pyroxene shows the characteristic cleavage, as indicated in the figure and also exhibits bright colors between the nicols, such as are seen in the pyroxene of figure 4. The feldspar looks impure and is filled with rifts and with numerous particles of chlorite and amorphous matter yet shows its characteristic bands of color between the nicol prisms. Hornblende sometimes replaces the pyroxene in these rocks, and is often present with it. The occurrence of these two minerals in the same rock is interesting, and the following analyses throw some light upon it. The first one is of a wholly chloritic kind, from Littleton; while the latter, from Pittsburg, is of a variety containing hornblende. The specific gravity of each is 2·96.

	Littleton.	Pittsburg.
Silica	45·56	48·79
Alumina	16·57	16·97
Ferric oxide	·36	1·69
Ferrous oxide	9·40	8·97
Manganous oxide	·20	·20
Lime	8·01	9·98
Magnesia	10·34	6·98
Potash	1·20	
Soda	2·55	3·30
Titanic acid	1·20	1·10
Water	3·93	2·65
Carbonic acid	1·02	
	100·34	100·63

On comparing these two analyses, little difference is seen between them, or between them and the corresponding igneous rocks. It will only be noticed that the one which is the more chloritic contains, naturally, more water and magnesia and less silica; hence, if in the rock represented by the second analysis the same chlorite was formed, and its amount was limited by the amount of water, there would be left a residue (corresponding to the remainder of chlorite in the first rock), which would make an aluminous hornblende; for there is little difference between the hornblende of which an analysis is given on page 132, and some chlorites save in the greater percentage of silica, and smaller of water, for the lime and magnesia are capable of replacement in either the hornblende or pyroxene. The conditions for the formation of both hornblende and pyroxene in a rock will be made a subject of further study. It seems to me to be dependent upon a low grade of metamorphism at a temperature below that which would have converted all into pyroxene and above that which would have determined it all to be hornblende. In view of the fact that the hornblende of

these rocks contains so large a proportion of alumina and also alkali, it will be seen how many combinations could be made from the same material. They both contain about two per cent of titanic iron and the oxygen ratio of the whole makes it probable that the feldspar is labradorite. There is present also some pyrite, and apatite or some mineral phosphate. For analysis, portions of the rock free from pyrites were selected; the phosphoric acid was not determined, but it was found to be present when a careful test was made, and the microscope reveals some minute crystals which appear like apatite.

3. *Organic remains in the metadiabase.*—In the microscopic study of these massive chloritic rocks, or metadiabase, I have found certain forms which appear to be of organic origin. Two of them are figured on plate V, in figs. 5 and 6.

Figure 5 represents a specimen from the metadiabase of Connecticut lake in Pittsburg. It has the structure of a tabulated coral, resembling much a *Chætetes;** but on account of its minuteness, in connection with other characters, there is little question but that it is a fragment of a rhizopod mass or foraminifer; and a close resemblance to a *Stromapora* will be noticed. The figure, like all the others, is drawn from a thin section of the rock, magnified thirty-five diameters. The breadth of the cells is hence but $\frac{1}{286}$ of an inch. These forms seem to be abundant in the rock; for, in a section of a fragment of rock half an inch square in surface, several bits of the fossil are sometimes found. The specimen figured is the most perfect that I have seen; but smaller fragments are abundant, and as they are apparently alike in dimensions, they sustain the supposition of the organic origin of all.

In the metadiabase of Hanover another form was found, which is represented in figure 6. This is very likely a section of a fragment of the same species of rhizopod cut in a different direction.

These forms, distributed through the massive rock, have a structure, as the figures show, which cannot be attributed to crystallization. They seem to make it evident that rhizopods must have been living over the sea bottom during the accumulation of these sediments, and became buried in the mud which is now the material of the rock. These forms are composed of silicates, but of what precise kind it is difficult to determine, since the particles are minute and their optical properties are obscure. Yet upon placing a drop of acid upon one of them it effervesced for a short time, showing that carbonate of lime existed in it—perhaps part of that of the original foraminifer.

The presence of these remains of rhizopods in the metadia-

* It also calls to mind the series of cells of a Bryozoan. See figures of *Lichenalia concentrica*, Plates 37 A and 40 E, Natural History of New York, Part VI, Palæontology, Vol. 2, by James Hall.

e is additional evidence of the sedimentary origin of these ks; and they also confirm the view that the metamorphism feeble in its degree, since it allowed of the preservation of se forms. It suggests, moreover, a source for the lime of labradorite and other minerals of the rock, as well as for its ·ite and phosphate. Associated with these rocks are exten- e beds of argillytes, which are scarcely altered. Everything nts to quiet waters during the original deposition; and finally gentle metamorphism.

. *Chlorite Schist. Metadiabase Schist.*—Metadiabase, by the elopment of a schistose structure, becomes metadiabase ist; or, as it is commonly called, chlorite schist. This rock ery abundant everywhere in the formation. It is schistose, ; the laminæ are often so firmly united that its structure is nifested only on fracture. It is distinguished from horn- nde schist by its light green color, and by giving off water en heated. Under the microscope the chlorite is crystalline l strongly dichroic. Its crystals are mostly in the plane of iination, and the pyroxene is in minute particles. A speci- n from Hanover, having a gravity of 3·03, was analyzed, by . Pease of the Sheffield laboratory, with the following result:

Silica	46·55
Alumina	19·26
Ferric oxide	2·58
Ferrous oxide	9·73
Manganous oxide	·25
Lime	9·07
Magnesia	6·67
Potash	·09
Soda	3·31
Titanic acid	·52
Water	2·39
	100·42

This rock which, as the microscope shows, contains but little nic iron, yet has more than twelve per cent of oxides of iron; l hence the analysis indicates a ferruginous chlorite contain- ; but little magnesia. The chlorite which best fulfills the iditions of composition and optical properties is the one ich occurs in igneous diabase—the diabantite;* and which ery apt to be formed in ferruginous rocks. If we consider water as an index to the amount of this chlorite, and the naining magnesia to indicate pyroxene, we find that the rock isists of 25 per cent of chlorite, 20 per cent of pyroxene, 1 · cent of titanic iron, and a residue nearly identical in com- sition with labradorite. These schists are sometimes highly

* This Journal, vol. ix, June, 1875.

porphyritic, and sometimes large crystals of feldspar are sparsely scattered through the mass.

Some of the metadiabase schist resembles closely specimens of the German *schalstein*, which like these is often associated with massive diabase, but which is considered to be the consolidated tuff that has resulted from the wear and tear of the massive igneous rock. The New Hampshire rock, as all the facts show, is unquestionably a result of the metamorphism of sediments, like the others of the greenstone series. These stratified kinds give us the plainest conceptions of the mode of origin of the whole.

5. *Metamorphic Doleryte.*—There is one more massive rock to which I refer on account of its lithological interest. It is the compound of pyroxene, triclinic feldspar and titanic iron, which is found at Littleton. The rock has the composition of a doleryte. Yet it contains diallage, or foliated pyroxene in large individuals, and hence it would be generally called gabbro. As the crystalline condition of the pyroxene seems to be an unimportant distinction, I here refer it to *metadoleryte*. The color of this rock is quite dark gray, and large orbicular crystalline masses of diallage are developed in a finely granular base. Its composition is as follows:

Silica	40·25
Alumina	13·62
Ferric oxide	5·46
Ferrous oxide	10·36
Lime	10·31
Magnesia	8·86
Potash	·59
Soda	1·96
Titanic acid	6·53
Water (ignition)	·74
	98·68

The microscopic structure of this beautiful rock is illustrated in figures 3 and 4 of Plate V. Fig. 3 represents the appearance of a thin section magnified thirty-five diameters, by ordinary transmitted light, while fig. 4 represents the appearance of the same between crossed nicol prisms. It contains as the figure and analysis show, a large amount of titanic iron, and hence the low percentage of the silica. Fig. 4, which illustrates the effect of polarized light shows the banding of the feldspar, which is either labradorite or anorthite. But the thing of most interest is the association of hornblende with the pyroxene. It is quite evident from a study of the section that the colored mineral was originally all pyroxene, and that it has now been partly changed into hornblende. That the horn-

blende resulted from the pyroxene is shown by the spots of hornblende in the pyroxene; the outline of these altered spots is quite indefinite and indistinct, indicating plainly the fact of change. When change of species takes place with no change whatever of chemical composition, it does not follow that the alteration should begin at the outside as in other cases, and as here seen this change began at the middle. Other crystals are seen to have so completely changed as to develop beautifully the cleavage of hornblende, while at the same time a good illustration of the cleavage of pyroxene is seen in the same slide. This alteration, which is not uncommon in other regions, is of much importance in New Hampshire, for in nearly all the trap rocks, the same change has taken place. It will be noticed that the pyroxene changes into a yellowish-brown strongly dichroic hornblende, and not into the bright green one which characterizes the original diorytes.

6. *Argillyte.*—In closing, I give an analysis of one of the non-crystalline rocks which abound in the region, in support of some of the views that have been advanced. The one that I select is from Woodville, and is a corrugated argillyte. The composition obtained is as follows:

Silica	60·49
Alumina	19·35
Ferric oxide	·48
Ferrous oxide	5·98
Lime	1·08
Magnesia	2·89
Potash	3·44
Soda	2·55
Water	3·66
	99·92

In this rock the microscope shows only incipient crystallization; yet it has a composition that would have made a good granite if circumstances had favored; but owing to the feeble degree of the metamorphism, the sediments of this composition were well nigh unaffected. The reason for this is seen in its small percentages of lime, magnesia and iron.

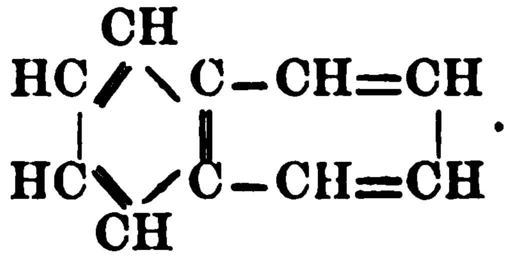
In conclusion, it appears from the facts described, that the greenstones of New Hampshire have been formed from fine sedimentary deposits which were accumulated in still waters; that the metamorphic action under which they were consolidated was quiet or gentle in degree, far different from that which in the adjoining regions has formed mountain masses of granite and gneiss, and hence that their special location in the region of metamorphic action, in connection with the nature of the sediments, has determined the characters of the greenstone series.

Sheffield Laboratory, New Haven, Conn.

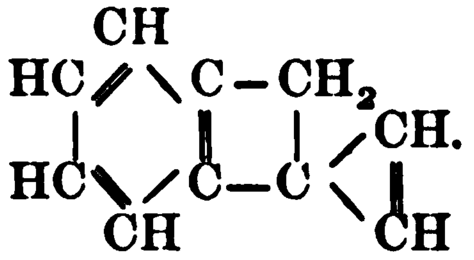
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

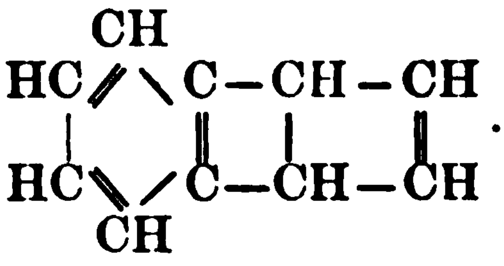
1. *On the constitution of Naphthalene.*—The constitution of the hydrocarbon naphthalene has been fixed, from its close analogy with benzene, as follows:—



Wreden has recently proposed two other formulas for this substance and has given his reasons for preferring them. These rational formulas are both unsymmetrical. The first is the most important, and is:—



The arguments offered are: 1st, the important pyrogenesis of naphthalene observed by Berthelot from styrene and ethylene, showing that the latter grouping is present. 2d, the decompositions of its molecule by oxidation and reduction. 3d, the mutual formation of decahydronaphthalene and hexahydrocymene by the reduction of naphthalene. 4th, the four possible monosubstitution derivatives indicated by the above formula, three of which have already been obtained. 5th, the formation of unsubstituted phthalic acid from dichlornaphthoquinone and of tetrachlorphthalic acid from pentachlornaphthalene is no evidence for the correctness of the symmetrical formula. 6th, the existence of two perchloronaphthalenes. And 7th, the existence of two analogous compounds, isomeric with styrene and acetenylbenzene, which this theory foresees may be synthesized from benzene and ethylene. The second formula, isomeric with the first, is:—



It differs from the symmetrical formula only in the mode of combination of the carbon atoms. Arguments 1, 4, 5, 6, and 7 apply also to it.—*Ber. Berl. Chem. Ges.*, ix, 590, May, 1876. G. F. B.

2. *Conversion of normal into iso-butyric acid.*—Erlenmeyer has observed a remarkable conversion of normal into isobutyric acid. In order to show the curious inversion of solubility in hot and cold water of calcium normal butyrate and isobutyrate, he

led up in glass tubes a cold saturated solution of the former l a hot saturated solution of the latter. This last tube on cool- ; deposited crystals while the first tube did the same on heating. ter repeating the experiment for class instruction many times, quantity of the normal butyrate crystals appeared to lessen heating, and on strong cooling crystals appeared resembling isobutyrate. This result careful examination confirmed. Since iling for eight days did not effect the change, time must be the quisite.—*Liebig's Ann.*, clxxxi, 126, May, 1876. G. F. B.

3. *On the Influence of Asparagin on Saccharimetry.*—CHAM- N and PELLET have studied the influence exerted by the rotatory wer of asparagin upon the indications of the saccharimeter. Its ueous solution (containing when saturated 1·66 to 1·72 per cent) ates the yellow ray $-6° 14'$; after adding ten per cent of am- nia $-10° 41'$. For white light the rotation $-11° 23'$ was ob- ned, corresponding closely with that of M. Bouchardat, $-11°$. On adding a mineral acid, the sign changes. An aqueous ution of asparagin containing 10 per cent of hydrochloric acid, a rotatory power of $+37° 27'$ for the yellow ray. Now since brimfaut has shown that beet roots contain 2 or 3 per cent of s substance, the indications of the saccharimeter are somewhat high, since the juice, although alkaline after clarification with sic lead acetate, still has a plus rotatory power. This error may ount to 0·7 gram of sugar in the 100 c.c. The authors find, how- er, that the rotatory power of the asparagin is entirely destroyed the addition of acetic acid. They recommend the addition to solution, after treatment with the basic acetate, of 10 c. c. of tic acid (at 8°) to every 100 c. c. The same fact to a less de- e is true of the juice of the cane. The authors propose the titer ore and after the addition of the acid, as a method for estimat- asparagin.—*C. R.*, lxxxii, 819, April, 1876. G. F. B.

4. *On the Alkaloid Aricine and some related Bodies.*—HESSE subjected to a new and exact investigation the cinchona alka- l discovered in 1829 by Pelletier and called aricine, obtained m a new bark *Cinchona pelleterana.* He comes to the conclu- n that aricine, as well as the cinchovatine of Winckler, and a v lævo-rotatory alkaloid discovered by de Vrij in 1873, are ntical in the pure state with cinchonidine. The alkaloid called cine by Howard, was probably paricine containing cinchonine. *Liebig's Ann.*, clxxxi, 58, May, 1876. G. F. B.

5. *Analysis of Mixed Liquids.*—DR. SIEMENS has designed an trument by which a stream of alcohol and water mixed in any portion, is measured in such a manner that one train of unter wheels records the volume of the mixed liquid; while a ond counter gives a true record of the amount of absolute alco- contained in it. The principle on which this measuring appa- us acts may be shortly described thus: The volume of liquid passed through a revolving drum, divided into three compart- nts by radial divisions, and not dissimilar in appearance to an linary wet gas-meter; the revolutions of this drum produce a

record of the total volume of passing liquid. The liquid on its way to the measuring drum passes through a receiver containing a float of thin metal filled with proof spirit, which float is partially supported by means of a carefully adjusted spring, and its position determines that of a lever, the angular position of which causes the alcohol counter to rotate more or less for every revolution of the measuring drum. Thus, if water only passes through the apparatus the lever in question stands at its lowest position, when the rotation motion of the drum will not be communicated to the alcohol counter, but in proportion as the lever ascends a greater proportion of the motion of the drum will be communicated to the alcohol counter, and this motion is rendered strictly proportionate to the alcohol contained in the liquid, allowance being made in the instrument for the change of volume due to chemical affinity between the two liquids. Several thousand instruments of this description are employed by the Russian Government in controlling the production of spirits in that empire, whereby a large staff of officials is saved, and a perfectly just and technically unobjectionable method is established for levying the excise dues. —*Nature*, xiv, 58. E. C. P.

6. *Viscosity of Salt-Solutions.*—M. GROTRIAN has determined the constants of friction of some salt solutions and their relations to galvanic electricity. The oscillations of a suspended disc with attached magnet (under the influence of a neighboring magnet) were observed in air and in the liquid under examination. The observed generally similar curve of temperature coefficients for fluidity and galvanic conductivity, with change of concentration, leads the author to conclude that the overcoming of internal friction forms an essential part of the work done by a current in passage through an electrolyte. In the case of chloride of potassium it is found that the increase of conductivity is almost exactly proportional to the percentage proportion (in the liquid); and Mr. Grotrian infers that the chemical changes he conceives generally to occur in chemical constitution of electrolytic molecules, on altering the concentration, do not occur here, but that with varied concentration, at the same temperature, the conductivity is only conditioned by the proportion of salt and the viscosity. With the numbers obtained in the experiments, it is possible to estimate for variously concentrated solutions of a salt, the temperatures for which the constants of friction have some determinate constant value; then to calculate the numbers for the conductivity at this temperature, and inquire according to what law these alter with the concentration. He thus shows that in the case of NaCl, KaCl, $CaCl_2$, and $BaCl_2$ the concentration and the viscosity are the principal factors, which determine the amount of the conductivity. —*Pogg. Ann.*, clvii; *Nature*, xiv, 142. E. C. P.

7. *Viscosity of Gases.*—HERR VON OBERMAYER has recently communicated a memoir to the Vienna Academy on the relation of the coefficients of internal friction of gases to the temperature. If we accept for the coefficients of friction μ at t° C. the formula

$\mu = \mu_0 (1+\alpha t)^n$ while α is the coefficient of expansion of the gas taken as a basis of the calculation, then the experiments of Obermayer give the following values of n:—Air, 0·76; hydrogen, ·70; oxygen, ·80; carbonic oxide, ·74; ethylene, ·96; nitrogen, ·74; protoxide of nitrogen, ·93; carbonic acid, ·94; ethyl chloride, ·98. The coefficient of friction of the permanent gases is, according to these experiments, approximately proportional to the $\frac{3}{4}$ power and that of the coercible gases to the 1-power of the absolute temperature.

For temperatures between 150° and 300° C. air gave the same values of n as between the lower temperatures $-21·5$ and 53·5. In the case of carbonic acid a slow decrease of the exponent n with the temperature was perceptible from the experiments.—*Nature*, xiv, 119. E. C. P.

8. *Simultaneous Sounding of two Notes.*—Dr. R. König sums up the results of an elaborate series of experiments of the effect of two tuning forks sounded together as follows:

I. (1) The number of beats of two notes n, n' is always equal to the positive and negative remainder of the division $\frac{n'}{n}$; that is, equal to the numbers m, m', which are produced by stating $n' = hn + m = (h+1)n - m'$, while n, n' are the number of double vibrations, and h the quotient of the division which gives the remainder m. It is as if the beats proceeded from the two overtones h and $h+1$ of the lower note n, between which the higher note n' lies. The cause of the beat-notes is simply the periodical coincidence of the common maxima of the two sound-waves.

(2) The beats of the pure harmonic intervals can be heard in the relations 1 : 8 and even 1 : 10, and may, as well as the beats of the unison, be regarded as resulting directly from the composition of the vibrations of the primary notes, without the help of resultant intermediate notes, whose existence cannot be proved.

(3) Both the beats m and the beats m', not only of the interval $n : n+m$, but also of the interval $n : hn+m$ ($h=2, 3, 4$), when the intensity of the primary notes and their number are sufficient, change into beat notes.

II. (4) When the two beat-notes m and m' are near the unison, the octave, and the twelfth, the same beats may be heard as would be produced by two equal primary notes. I have named these beats arising from beat-notes secondary beats, in order to distinguish them from the beats arising from primary notes.

(5) When the intensity of the beat-notes by which they are formed and their numbers are sufficient, these secondary beats change to a secondary beat-note, as primary beats change to a primary beat-note.

III. (6) The difference-notes and summation-notes, which are produced by the change of two loud notes (the vibrations of the latter not being infinitesimal), produce a phenomenon which is independent of the beats and beat-notes; they are only much weaker than the beat-notes.

IV. (7) The beat-notes cannot be explained by reason of the difference-notes and summation-notes, because the number of their vibrations is in many cases different from what this cause might produce.

(8) The audibility of the beats depends solely upon their number and upon the intensity of the primary notes, and is independent of the distance of the interval.

(9) The number of the beats and of the primary impulses in which both may be perceived as separate impulses is the same.

(10) With the beats perceived as separate impulses, as with the primary impulses perceived in the same manner, the note which approaches them in number is audible.

(11) The number at which beats and primary impulses can change into one note is the same.

(12) As with beats and primary impulses, the intermissions of a note can also change into one note.

(13) When the vibrations of a note vary periodically in intensity, the periodical maxima of vibration change into one note, if their number is sufficient.

(14) The beat-note which is formed by two primary notes must always be weaker than the latter, although single beats are stronger than the notes which form them.—*Phil. Mag.*, l, 417, 511. E. C. P.

II. Geology and Mineralogy.

1. *Critical Observations on Theories of the Earth's physical evolution;* by Capt. C. E. Dutton. (The Penn Monthly, May and June, 1876.)—Captain Dutton presents in this paper the views brought out in his article in volume viii of this Journal, with fuller illustrations, and adds explanations of his theory of the origin of mountains. The discussion should be read by all desiring to reach right conclusions, it presenting many arguments from physical considerations against the contraction-theory, or that of the uplifting and folding of strata through lateral pressure. There is much to be learned before any theory of mountain-making shall have a sufficient foundation in observed facts to demand full confidence, and Captain Dutton merits the thanks of geologists for the aid he has given them toward reaching right conclusions. His discussions are not free from misunderstandings of geological facts, and if they fail to be finally received it will be for this reason. The subject is too large a one for a full statement, in a book-notice, of the apparent difficulties and sources of doubt which might occur to an advocate of the latter theory.

We here give in a brief form, and nearly in his own words, the principal points in his theory of mountain-making as explained in the later part of his memoir.

Accepting the proposition that there is a plastic condition of rock beneath the earth's crust and that metamorphism is a "hydrothermal process," and believing that "the penetration of water to

profound depths [in the earth's crust] is a well sustained theory," he says that great pressure and a temperature approaching redness are essential conditions to metamorphism; that the state of silica, alumina, etc., in the process, is like that when these oxides are obtained in the soluble hydrous condition, and therefore they would have had less specific gravity than they have in the crystalline anhydrous condition; and that a diminution of heat or pressure would have been followed by crystallization and an increase of density; that the deeply buried rocks would require but little expansion to cause a diminution of specific gravity; and, if they become highly plastic from any cause, then the position of the superior or overlying strata would be one of unstable equilibrium; if heated without becoming plastic, or if plastic and yet denser than the overlying beds, the expansion would cause a vertical upward movement and attendant results, including in some cases great fractures owing to inequalities in bedding and texture and the consequent unstable equilibrium; that the axes of maximum deposit would become the axes of future synclinals, because "the heaviest portion would sink into the lighter colloid mass" underneath, protruding it laterally beneath the lighter portions where, by its lighter density, it tends to accumulate." He adds: "The resulting movements would be determined, first, by the amount of difference in the densities of the upper and lower masses, and, second, by inequalities in the thickness of the strata: the forces now become adequate to the building of mountains and the plication of strata, and their modes of operation agree with the classes of facts already set forth as the concomitants of those features."

The views are next applied to a system of plications. "It has been indicated that plications occur where strata have rapidly accumulated in great volume and in elongated narrow belts; that the axes of plications are parallel to the axes of maximum deposit; and that the movements immediately followed the deposition"—the case of the Appalachians being an example in which the accumulations averaged 40,000 feet. He observes: "Wherever the load of sediments becomes heaviest, there they sink deepest, protruding the colloid magma beneath them to the adjoining areas, which are less heavily weighted, forming at once both synclinals and anticlinals. If the difference in the densities of the upper and lower portions be small, the latter being a little less or but slightly plastic, the disturbance would not be great [and the undulations made would be low]; if this difference and the plasticity be considerable, the disturbance becomes not only greater, but assumes new phases [as in the Juras and Appalachians]; and finally when the two conditions become extreme, the phenomena become eruptive." The movements are hence according to hydrostatic law. He says farther: "In mountain-making the disturbing agents have been extreme. All typical mountains consist of granitoid cores protruded through strata and towering above them"—as in the Sierra Nevada. "The thickness of the

Appalachians is from five to eight miles; the thickness of the Miocene strata of the Coast Range in California, according to Messrs. Brewer and King, is nearly five miles [5000 feet?]; and both systems bear every indication of being shallow-water deposits —in brief, coast and off-shore deposits. No geologist doubts that these strata subsided as they grew in thickness. But if they subsided they displaced the matter beneath them; and what becomes of the displaced matter?" In the case of the Appalachians "it must have gone to the south-eastward—toward the land whence the sediments were derived"—"the direction toward which gravitation would inevitably propel it." "In the Coast Range, the Uintahs, Wahsatch and the Park Mountains of Colorado, strata miles in thickness have sunk, and right at the upturned edges come up the towering granitoid mountains." "On the one hand, matter has been displaced and gone somewhere [southeastward], on the other, displaced matter stands revealed in immediate contiguity." The Uintah range is a good example. "Disregarding the enormous Cretaceous deposits, the freshwater Tertiaries turned up on the flanks of these mountains are 10,000 feet thick. That these beds subsided by their gross weight as rapidly as they grew admits of no shadow of doubt." "What became of the matter displaced by the sinking strata, and whence came the displaced matter which slopes down to their upturned edges, and how can the conclusion be avoided that they are one and the same?" In other words the granitoid core was extruded as the sinking went forward, or during the later part of it.

For further details respecting the theory we refer to the original memoir.

With regard to this new theory, we might reasonably question the existence of the colloid magma—a condition fundamental to the theory—and his evidence that water penetrates to profound depths in the earth's crust sufficient to make hydrous rocks. We might ask for evidence that the rocks beneath the Cretaceous and Tertiary, and other underlying strata of the Uintahs, were in such a colloid state, and this so near the surface, that the "beds subsided by their gross weight as rapidly as they grew." We might query whether, if the subsiding of the beds were causing at the same time a protruding, the seas would have been in a condition for living species or quiet deposition, and whether therefore the protrusion, if a fact, must not have been a final result after the deposition and the attendant subsiding had ended. We might query whether the granitoid core of some of the mountains referred to has been proved to be of the age the theory assumes. We might query also whether in the case of the Appalachians, the material of which the rocks were made came from land once existing to the southeastward; whether the various anticlinals and synclinals in different overlapping series, taking only the larger ones, could have corresponded severally to movements in a colloid mass below, to a sinking by weight where the material was thickest above, and so making the synclinals; whether in the case of the Appalachians,

the width of the synclinal formed as the Paleozoic deposits were in progress was not approximately as great as the width of the area of thickening depositions, and whether the anticlinal, made by the displaced plastic material beneath being pushed to the southeastward, was not at least as broad as the synclinal, so that one anticlinal and one parallel synclinal may have occupied together three hundred miles or more in breadth.

Captain Dutton observes that "plications occur where strata have rapidly accumulated in great volume," etc. This idea of *rapid* accumulation and brief work in mountain-making has occasioned, as shown in this and some other parts of his memoir, some misapprehension of the effects that would come from lateral pressure. The accumulation of material for the Appalachians, occupied the whole of Paleozoic time; and probably there is no geologist who believes that the length of that era was less than ten millions of years, and few that it was less than fifty millions. Even if it took one million, the accumulation was not rapid; and certainly not if it took fifty millions. Again, he says that the movements of mountain-making "immediately followed the deposition." "Immediately" sounds quick to one who appreciates the slowness of geological changes. The Carboniferous age was very long; and some where in that part of geological time, either before the age had fully ended, or some time after its close, the epoch of catastrophe began. But this catastrophe, according to the apprehension of geologists who best appreciate the rate of the earth's progress, may have taken one or more hundreds of thousands of years to have accomplished its results—time enough to have produced plications without chaotic effects.

2. *A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country;* by F. B. MEEK. 609 pp. quarto, with an Introduction of lxiv pages, and 45 quarto lithographic plates, of about 1000 figures, constituting volume ix of the Report of the U. S. Geological Survey of the Territories, F. V. HAYDEN, U. S. Geologist in charge.—Mr. Meek's labors in connection with the Cretaceous and Tertiary fossils of the Rocky Mountain region began more than thirty years since, and, with some interruptions by work on the paleontology of other parts of the country, they have been continued ever since. He was engaged in the descriptions of the earliest invertebrate fossils collected in Nebraska by Dr. Hayden, and has always been referred to for descriptions of the species of the expeditions under Dr. Hayden's charge, and not of these alone. For the preparation of this new and great work he has therefore had the benefit of his previous long and labored study of the subject, and the command of all the species the Rocky Mountain expeditions have afforded. Mr. Meek works with extreme care and fidelity, and hence his results rank with the best.

The country in which the fossils described in his work were discovered lies mainly between the British possessions on the north, the Platte on the south, the Missouri River on the east and the Rocky Mountains on the west.

The Introduction to the volume, after presenting sketches of the earlier explorations in the Upper Missouri region, describes the formations from which the fossils were collected, giving sections showing the thickness and order of superposition of the various subdivisions. The geographical extension of the same west of the Mississippi is also shown; and their relation to the subdivisions of the Cretaceous in Mississippi, Alabama, New Jersey, and in the Old World are fully discussed. The author also makes some remarks on the mooted question in regard to the relation of the Lignites of the far-west to the Cretaceous and Tertiary systems, maintaining, as he had previously done, that these deposits belong in part to the Cretaceous and in part to the Tertiary: that is, that the beds at Coalville, Utah, and Bear River, Wyoming, are clearly Cretaceous, like those of Western Colorado; that those of Bitter Creek, Wyoming, especially those below the horizon of the Hallville coal, are almost certainly Cretaceous; that those above, to the horizon of the Saurian bed at Black Butte Station inclusive, probably belong also to the Cretaceous, but may be Eocene; and that the Evanston and Carbon Station coal-bearing strata of Wyoming are Tertiary.

The Judith river fresh- and brackish-water beds of Montana, and of British America, in which Cretaceous types of Saurians have been found, along with some Eocene types of vertebrates, and new species of shells that would be called Tertiary forms by almost any paleontologist (judging from their affinities), he thinks, *may* be Cretaceous, but he does not regard this conclusion as yet clearly established. The Fort Union fresh- and brackish-water Lignite group, of the Upper Missouri he regards as Tertiary.

In the body of the work, all of the known Upper Missouri invertebrate genera, subgenera, species and varieties, whether new to science or not, are fully described; and are also illustrated on the accompanying plates. The genera thus described number about 120, the subgenera, including the type sections, 170, and the species and varieties about 308. Full synonymy and references of all of the species and genera are given, and the type of each genus and subgenus, where known, is mentioned; and, where there is doubt as to the exact type-species, a typical example is cited. After the description of each genus a separate brief diagnosis of its subgeneric sections (if so divisible) is given, and an example cited.

The affinities and geological range, so far as known, of each genus, are also fully discussed; and when represented by existing species, its habits and geographical distribution are generally stated. Most of the species, and some of the genera in the work, are here for the first time illustrated.

Only a few of the species are known to occur in the old world, and at localities in this country east of the Mississippi; and these are all from the Cretaceous, and show that the Niobrara and Fort Benton Groups, as well as perhaps the Dakota Group, represent the Lower or Gray Chalk, with possibly also the Upper Green Sand;

and the Fort Pierre and Fox Hills Groups the Upper White Chalk, and, possibly, also the Maestricht beds of Europe.

3. *Shower of Volcanic dust over Scandinavia.*—In March of 1875, according to A. E. Nordenskiöld, a shower of volcanic dust fell widely over Sweden and still more abundantly over Norway, making a layer over some places a quarter of an inch thick. The dust was pumice-like in constitution. It is traced to Iceland. On the 30th of March the winds were northwest and west. An eruption began in Iceland in the preceding December, from numerous craters in the interior, and the most abundant ash-shower occurred over the island on the 29th of March, covering some pastures six inches deep; and if the ashes of the same shower reached Scandinavia, as is probable, the journey of 2000 kilometers was performed in less than twenty-four hours.— *G. Mag. for July.*

4. *Carrara Marbles.*--Prof. G. A. Lebour, in the Geological Magazine for July, mentions the discovery of Sub-carboniferous fossils in connection with Carrara statuary marbles; among them *Spirifer glaber*, *Leptæna arachnoidea* d'Orb., *Cardiomorpha pristina* de Kon., *Cardinia tellinaria* de Kon., *Pholadomya regularis* d'Orb., *Cyathocrinus quadrangularis* Miller, etc. The superior Coal-measure shales, at Monte Jano, contain *Neuropteris rotundifolia* Brngt., *Odontopteris Schlotheimii*, *Pecopteris arborescens*, *P. cyathea*, *Cyclopteris orbicularis*, *Annularia longifolia*, etc.

The St. Béat marbles, in the Pyrenees, are of the same Carboniferous limestone age.

5. *Markings supposed to have been made by man with stone implements on bones of a Balænotus of the Lower Pliocene of the valley of Fine, Italy.*—Capellini who described these markings to the R. Accademia dei Lincei, at the meeting of May 7th, states that the Balænotus was the same species described by Van Beneden from the Tertiary of Belgium. The marl-bed, containing the bones, he identifies with the Superior marl of the Vatican, belonging to the Lower Pliocene. His memoir will soon be published, with a plate.

6. *Serpentine and Eozoon.*—Dr. Dawson has a reply to the criticisms of Mr. Hahn, in the number of the Annals and Magazine of Natural History for July, and Dr. William Carpenter in the number for June. Dr. Carpenter mentions the discovery, by Prof. Möbius, of Kiel, in 1874, on a coral reef off Mauritius, of an incrusting foraminifer, which, in mode of growth and peculiarities of structure, approaches rather closely the Eozoon.

Dr. Dawson states that Mr. Richardson has found at Chibogomon, Canada, in a great bed of olive-green serpentine (a kind analyzed by Hunt) a specimen of tabulate coral, having many of its thin-walled hexagonal cells filled with serpentine, while others were filled with chlorite; and that a dark-green serpentine from Melbourne, Canada, envelopes fragments of shells, crinoids and corals, and also penetrates their pores and cavities.

Dr. Dawson has described (Quar. Jour. Geol. Soc., Feb., 1876) specimens of *Eozoon Canadense* from Côte St. Pierre, in the

Seigniory of Petite Nation, on the Ottawa, in a limestone of the Grenville band of Sir W. E. Logan, resting on bedded dioryte. Serpentine occurs in the limestone with the Eozoon, and also there is some dolomite, much of it without the Eozoon structure.

7. *Experiments on Schistosity in rocks, and on the deformations of fossils attending its production;* by M. DAUBRÉE (C. R., lxxxii, March 27 and April 10, 1876.)—The production of foliation in rocks is here discussed at length and illustrated by facts from experiments; and the results are made by Daubrée to include all examples of a schistose structure. His experiments were made by the hydraulic press used by M. Tresca in similar researches, and under the advice of this physicist. Clay containing fine sand forced through a cylindrical aperture was rendered foliaceous concentric with its surface; and if mica were mixed with it, the foliaceous structure was very perfect, the mica scales having taken a position parallel to the surface. The same micaceous clay forced through a rectangular aperture became foliaceous parallel to the surfaces of the rectangular prism obtained, the most of the mica being parallel to the larger faces. The larger the scale of mica the more perfect the parallelism. These clays thus made foliaceous called to mind, strongly, M. Daubrée observes, the foliaceous character of mica schist and gneiss. By the same process, the compression of fossils was illustrated and also the occasional subdivision of one into a series of separated parts. A belemnite was too firm to answer for the experiment; but a piece of chalk cut into the form of a belemnite. gave precisely the fracture and separation of parts so often seen.

Daubrée states that in the production of the foliated or schistose structure, there is a sliding of the parts unequally *in the direction of the pressure and movement;* and this is its origin. It is not necessary that the substance should consist of visible particles; for Tresca obtained the structure even with metallic lead. Moreover a very slight movement is sufficient to produce a distinct foliation; and a slow one conducts to the same result as a rapid.

From the experiments Daubrée draws the wide conclusion that the schistose structure in gneiss and mica schist, as well as that seen less perfectly in some granite, may have been produced *by pressure and movement;* and that in the region of Mont Blanc, for example, movement under pressure of the protogine material when pressed out in a plastic condition was the cause of all the schistosity the rock presents.

Where gneiss, mica schist, quartzyte, limestone occur in alternating beds, as is often observed, with the foliation parallel to the planes of junction, they must of course be regarded as successive strata, and as foliated parallel to the bedding in consequence of the original bedding. This is sometimes proved to be the case by the presence of more or less perfect fossils in the limestone. Hence, the question whether in any special case, the schistose structure of gneiss or mica schist was occasioned by pressure or not, is to be ascertained by a direct study of the rocks in place.

8. *The Geological and Natural History Survey of Minnesota;* 4th Annual Report, for 1875; by N. H. Winchell, State Geologist, assisted by M. W. Harrington. 162 pp. 8vo. St. Paul, Minn. 1876.—This report contains a Report on Fillmore County, by Prof. Winchell, and others, on Olmstead, Dodge and Steele Counties, by Mr. Harrington, together with a long table of railroad elevations, and a Report on the General Museum, by Prof. Winchell. Colored geological maps are given of each of the above named counties, and also good illustrations of some of the rock-scenery. One of the latter represents a bluff of the Jordan sandstone at Lanesboro, with a remarkable concretionary structure, the concretions of which vary from a few inches to nearly a foot in diameter. The St. Lawrence limestone, Jordan sandstone and Shakopee limestone underlie the St. Peters sandstone and correspond to the Lower Magnesian limestone.

9. *Rèvue de Géologie* of Messrs. Delesse and Lapparent. Vol. xii for 1873 and 1874. 224 pp. 8vo. 1876. (P. Savy, éditeur).—A very convenient volume for the geologist, posting up the new facts and discoveries in lithological, stratigraphical and dynamical geology. We cite from it the following observations:

M. Gérardin has shown that the waters of subterranean streams, feeding artesian wells, contain no oxygen, as Péligot had before shown to be true of the water of Grenelle.

According to M. Ed. Jannettaz, the conductibility for heat of slaty rocks is much the greatest in the direction of the slaty structure. Thus the ratio is in a talcose slate (a hydromica slate?) from the United States 2·007; in argillyte (phyllade) 1·988; mica schist from Aurillac (Cantal) 1·82; in a ferruginous talc slate (hydromica slate?) making part of the itacolumites of Guyanne, 1·87; an argillyte of Angers, 1·6.

M. Cossa has observed that gneiss, granite, trachyte, basalt are decomposed more rapidly by water holding gypsum in solution than by pure water. Sæmann and Guyerdet have found that dolomite is easily decomposed by the same solution aided by a current of carbonic acid.

10. McCoy, *Paleontology of Victoria:* Geol. Surv. of Victoria; Decade III. 40 pp. roy. 8vo. Melbourne. (London: Trübner & Co.).—This decade contains descriptions and figures of remains of *Thylacoleo carnifex*, of some trilobites (species of Phacops, Forbesia, Lichas, Homalonotus), and of various Mollusks.

11. *Report on a Survey of a line to connect the waters of the Neuse and Cape Fear River in North Carolina, and of a line to connect the waters of Norfolk Harbor in Virginia, with the waters of Cape Fear River at or near Wilmington in North Carolina;* by Mr. S. T. Abert, U. S. Engineer. Engineer Dept. Senate Ex. Doc., 44th Congress, No. 35.—This Report contains much valuable matter on the physical features of the coast region of North Carolina and Virginia, and of the changes which have been and are still going on there as to the limits and depths of the Sound, and the extent and outline of the sea-made lands, and on the origin of those changes.

12. ***Mines and Mineral Statistics of New South Wales***, compiled by direction of the Hon. John Lucas, M.P., Minister for Mines. 252 pp. 8vo, with maps and sections. Sydney, 1875.—Besides mining statistics, this volume contains much of geological interest. It includes an essay on the sedimentary formations of the country, by Rev. W. B. Clarke, and notes on the Iron and Coal deposits of Wallerawand and on the diamond fields, by Prof. Liversidge.

13. ***Recently formed crystallized minerals of the thermal spring at Bourbonne-les-Bains.***—Brief notices of Daubrée's examinations of the remarkable mineral transformations at Bourbonne-les-Bains have been given in volume x of this Journal, at pages 228 and 391. They were from abstracts of his communications to the Académie des Sciences in 1875, in the Comptes Rendus, lxxx, 461, 604 and lxxxi, 182, 834, 1008. The completed memoir has recently been published with some additions, and is issued as a pamphlet of 48 pages, by Dunod, Paris. It is a thorough discussion of the characters, conditions of occurrence, and modes of origin, of the several species, together with many valuable suggestions as to the bearing of the various facts on problems in geology. We cite the following points, not alluded to in the previous notices. The minerals derived from the action of the water on bronze objects (medals, etc.) include, besides those mentioned, also cuprite, chrysocolla, oxyd of tin and melaconite; and those from the action on lead tubes, cerussite (carbonate of lead). Daubrée remarks that while the copper had formed sulphids, the tin of the bronze had changed to the oxyd, which is its usual condition in metallic veins. Cuprite (oxyd of copper) was found in octahedral crystals in a tube of bronze, along with melaconite and chrysocolla. One of the specimens of phosgenite was associated with crystals of anglesite and had the cubic form of galenite. Oxyd of lead or litharge is still another of the lead products.

The iron found in the baths has in some places given rise to a hydrous silicate of iron, gelatinizing with acids, as had been observed by Daubrée also at Plombières. Vivianite is another of the iron minerals.

In addition to the zeolites, chabazite, and harmotome, there is one in regular hexagonal prisms which Daubrée refers with a query to the species *chalcomorphite*. Still other species are aragonite and calcite, and an earthy hydrous alumina silicate, related to halloysite or the material known as *Savon de Plombières*.

The whole number of crystallized species found to have been formed in the bottom of the old Roman well is at least twenty-four. Daubrée remarks that they may be looked upon as results of experiment although the experiments have been in progress through twenty times the duration of a human life. The water contains only neutral salts in solution, and has a temperature from 58° to 68° Centigrade. It has made different compounds according to the different materials that were bathed by it; and these are of so various kinds as to illustrate well the association of minerals in some metallic veins. The changes were produced at

Bourbonne, as they were also at Plombières, within eight meters of the surface, and at a temperature but little elevated; how great, then, asks Daubrée, must be the transformations we should witness if we could descend to the deeper parts of the conduits of thermal waters; and what the changes that must have gone on at all times through the waters penetrating the earth's deeper rocks and fissures.

14. *Further notes on inclusions in Gems*, by ISAAC LEA, LL.D. 11 pp. 8vo. Philadelphia, 1876.—Dr. Lea, in continuation of his former paper on this subject, describes cavities and minute crystals observed by him in tourmaline; of a cubic form and including a fluid, in an emerald; blue, and 4-sided, in iolite; tubular cavities, with a cubic crystal with fluid in one cavity, in blue corundum of North Carolina; minute acicular crystals in corundum of Delaware Co., Pa., producing a bronze-like luster; and other results of his observations. The paper is accompanied by a lithographic plate.

15. *Geological Map of Europe.*—A small colored geological map of Europe showing the distribution of stratified rocks has been recently published in Petermann's Geographische Mittheilungen. It was prepared by Habenicht, and is an excellent map for one of the size—12½ by 15½ inches.

16. *New Minerals: Ihleite, Friedelite.*—Prof. Schrauf has announced a new mineral under the name *Ihleite*. It occurs as a yellow efflorescence on the graphite of Mugrau, Bohemia. Its composition is expressed by the formula $Fe_2S_3O_{12}+12H_2O$. (Anzeiger, Ak. Wien, March, 1876.) *Friedelite* is a hydrated silicate of manganese described by M. Bertrand. Its characters are as follows: Rhombohedral. Cleavage eminent, normal to the vertical axis. Two varieties, one with saccharoidal structure, the mass made up of hexagonal lamellæ, with perfect cleavage, and the other very compact, with the cleavage scarcely visible. Double refraction energetic, axis negative. H.= 4·75, G.= 3·07. Color rose-red; streak pinkish-white. Transparent in thin fragments, in the mass translucent. Composition, the mean of several analyses: SiO_2 36·12, MnO 53·05 (FeO tr), MgO, CaO 2·96, H_2O 7·87=100. Both varieties mentioned give the same composition; in fact they pass into one another. M. Bertrand writes the formula 4MnO, $3SiO^2$, $2H^2O$ ($Mn_4Si_3O_{12}$+2aq), and remarks that it seems to be somewhat similar to hydrotephroite (Dana, Min. 1868, p. 260). B.B. fuses easily to a black glass; in the closed tube gives water. Dissolves in hydrochloric acid with the separation of gelatinous silica. With the fluxes reacts for manganese.

Found at the manganese mine of Adierville, valley of Louron (Hautes Pyrénées).—*C. R.*, May 15, 1876. E. S. D.

17. *Analcite not isometric.*—Prof. Schrauf, (l. c.) from an examination of analcite crystals from Friedeck, Bohemia, concludes that the species (like leucite) cannot be referred to the isometric system. The simplest crystals show evidence of repeated twinning, and the angle between the cubic planes is 89° 30′, implying the

existence of a dome as twinning plane, with an angle of 44° 45′, and giving the axial ratio 1 : 0·991. Irregularities in the optical properties of analcite were observed by Brewster. E. S. D.

18. *Angewandte Krystallographie* (*Ausbildung der Krystalle, Zwillingsbildung, Krystallotektonik*) *nebst einem Anhange über Zonenlehre*, von A. SADEBECK. 284 pp. 8vo, with 23 plates. Berlin. 1876.—The present volume forms properly the second part of the Elements of Crystallography (of G. Rose) published by Prof. Sadebeck in 1873. The object of the work is to describe crystals as they actually appear in nature, not the ideal forms which are of only theoretical existence. The special subjects considered are: 1. hemimorphism and pseudo-symmetry, the latter arising from the natural distortion of crystals in certain axial directions; 2. twins, including their explanation theoretically, and also an enumeration of all the methods or laws of twinning observed in the different systems; 3. the method of growth of crystals, showing how each individual is gradually built up of minute sub-individuals, and thus giving an explanation of many irregularities observed not only on the surfaces of the planes, but also in the interior of crystals. This last subject is one of great theoretical interest, and in the discussion of it the author has introduced much matter which is new obtained from his own extensive researches; it is elucidated by many excellent figures. The last chapter of the work discusses the subject of zones, considered particularly by means of the Quenstedt method of projection.

E. S. D.

19. *New Journal devoted to Mineralogy and Crystallography.*—Professor Groth, in a letter to the editors dated Strasbourg, May 28th, 1876, announces the commencement of a new Journal for special mineralogy. The plan of this Journal embraces the following subjects:—theoretical, physical and chemical crystallography; investigations in regard to artificial crystals; monographs of single minerals especially in relation to crystallography; memoirs on the chemical composition and artificial production of minerals, descriptions of their methods of occurrence, their determination under the microscope; in a word the Journal will cover the whole field of mineralogy, with the exclusion of geology. The leading mineralogists of Germany and Austria are all interested in the project, and it is desired that those of other countries should also lend their support so that the Journal may gradually assume an international character. In addition to the original papers it is proposed to include references to mineralogical work wherever published. There are to be from six to eight numbers during the year, appearing every six or eight weeks with the exclusion of the vacation months. The chief editorial duty will be performed by Prof. Groth, with the especial coöperation of Prof. G. vom Rath of Bonn, and Prof. Klein of Heidelberg. The publisher is Engelmann of Leipzig.

The plan deserves the hearty support of all interested in this department of science.

III. Botany and Zoology.

1. *The Oaks of the United States;* by Dr. George Engelmann. Reprinted from the Transactions of the Academy of Science, of St. Louis, Missouri, vol. iii, no. 3. 1876.—Only 20 pages; but they are wholly to the purpose, and contain the leading results of the long and close scrutiny which Dr. Engelmann has given to this vexed genus of trees. The paper begins with an account of the deceptive character of the common western oaks, as exemplified by the common scrub oak of the Rocky Mountains, basing his narrative upon his personal observations of its forms in the valley and on the bordering bluffs and precipices, where the Arkansas leaves the mountains at Cañon City, Colorado. Here, at different heights and exposures, he found *Quercus Gambelii* (*Q. stellata*, var. *Uthensis*, DeC.), *Q. Gunnisoni*, *Q. undulata*, described by Torrey long ago from this district, *Q. pungens* of Liebman, in part, *Q. oblongifolia*, *Q. grisea*, and *Q. Drummondii* of Liebman,—"in herbarium specimens all distinct enough, but, looking around us, the very abundance of material must shake our confidence in our discrimination [since] within the compass of a few hundred yards we find not only the forms above distinguished, but numbers of others, neither the one nor the other, but which are intermediate between them, and clearly unite them all as forms of one single, polymorphous species. If one oak behaves thus, why not others? Thrown upon a sea of doubt, what can guide us to a correct knowledge?"

Dr. Engelmann reviews the principal characters, one by one, to settle their relative value; and, in doing so, brings out the main general results of his protracted and patient investigations in this field. The trunk, as to size attained, while it gives character to eastern species (only the southern live oak occurring both as large tree and shrub, and equally fruitful in both forms), fails on the Pacific slope to be a specific distinction. "Examining the ***bark***, we at once become aware of the fact that the popular distinction between 'white oaks' and 'black oaks' is based on correct observation. The paler, ashy-gray bark of the former, and the darker or often nearly black color of the latter, correspond with the essential characters, and mark the two principal groups of our American oaks. The bark of the white oaks is inclined to be scaly or flaky, that of the black oaks is usually rougher and deeply cracked or furrowed." "Moreover, the *wood* of the white oaks is tougher, heavier, and more compact; is the only oak wood fit to be used by the wheelwright or cooper, and is, for their purposes, unsurpassed. The wood of the black oaks is brittle and porous, makes poorer fire-wood, and in barrels holds only dry substances." Dr. Engelmann states that, "instead of making narrower and narrower rings as they grow older, the oaks either hold their own, the annual rings being as wide in age as in youth, or they grow more rapidly after the first 50, 100, or even 150 years of their existence."

The winter buds give characters in some species. As to the shape of the leaves, so extremely variable, it is remarked, "that those oaks, which in the perfect state have deeply lobed or pinnatifid leaves, show in young shoots and on adventitious branchlets less divided or even entire leaves; while, singularly enough, the oaks whose leaves in the adult tree are entire, or nearly so, often have on the young shoots dentate or lobed leaves."

The vernation of the leaves, although more commonly conduplicate, both in white and black oaks, furnishes other types, which Dr. Engelmann has first brought into prominent view, and finds of great account in distinguishing allied species and doubtful varieties, and in unravelling intricate questions of hybridity or affinity. The nature of the down on young leaves may also be turned to use. The venation occasionally enables easily confounded species, such as *Q. agrifolia* and *Q. Wislizeni*, to be distinguished even in sterile branchlets.

The persistence of the leaves is a good character in some species, while in others it is of no account. The leaves of some oaks persist even to the third year. "Only such oaks ought to be called evergreen which retain the greater part of their old leaves, at least until the new ones are fully grown."

In the male flowers the size and number of the anthers furnish good distinctions, being small and mostly 5 to 10 in the white oaks, four or sometimes 5 to 6 and larger in the black oaks; the pubescence of the anthers distinguishes a few species, while their cusp is variable in several. The female flowers distinguish the principal groups, especially the styles, which in the white oaks are sessile or nearly so; in the black oaks always on longer and spreading or recurved styles. The annual or biennial maturation of the acorn, first indicated by Michaux, and the persistence and position of the abortive ovules, indicated by Alph. DeCandolle (in white oaks at the base, in black oaks near the tip of the perfect seed), and the scales of the acorn cup (thick and knobby in white, thin and membranaceous in the black oaks), are likewise noted. The comparatively thin shell of the acorn in white oaks is dark and smooth within, or rarely pubescent; in the black oaks the shell is thicker and lined with a silky down.

All these matters relate to the true oaks (section *Lepidobalanus*), with scaly acorn-cups, pendulous male catkins wholly apart from the solitary or distant female flowers. But in California we have, in *Q. densiflora* a representative of the otherwise Asiatic subgenus, *Androgyne*, "in many respects more a chestnut than an oak; for it has, just like the chestnuts, dense-flowered and erect male spikes, 10 stamens to each flower, very small anthers on long filiform filaments," female flowers crowded at the base of the male catkins, linear pointed stigmas, and a spinose cup, which, however, is that of an oak rather than like the prickly involucre of the chestnut.

The paper continues with a systematic enumeration of the 38 recognized species, and notes are appended to about half of them.

Finally, hybrid oaks are discussed; and six well determined ones are enumerated as known to the writer, three of which have been described as species, namely: *Q. Leana*, *Q. tridentata*, and *Q. sinuata*. One parent of four of these hybrids is *Q. imbricaria*; of the other two, *Q. cinerea*. The fact that some species of a genus are more prone to hybridize than others—which is also true of *Verbena*—is curious. Most botanists will learn with some surprise that *Q. heterophylla* of Michaux is received, not as a hybrid, but as a well-marked species, of the *Phellos*, *laurifolia*, and *aquatica* group. Dr. Engelmann's six real hybrids are all of the Black oak group: this group never crosses with White oaks; and no hybrid of the latter group is known to our author. The black oaks are now unknown in Europe; but we learn that they existed there, along with white oaks, in the tertiary period.

It must be difficult to discriminate between hybrids and intermediate forms of variation where the usual character, the sterility of the hybrid, is wanting, "and where we have nothing to rely on but the rarity and individuality of a form that seems to stand intermediate between two well established species which occur in its neighborhood, and which could be considered its parents. This is just the case in Oaks. All the supposed hybrids are abundantly fertile, and those of their acorns that have been tested have well germinated; in fact, as far as I know, no difference in fertility or germinating power between them and the acknowledged species has been discovered. The seedlings of such questionable individuals do not seem to revert to a supposed parent, a sport of which they might claim to be, but they propagate the individual peculiarities of the parent--'come true,' as the nurserymen express it. At the same time it is a remarkable fact, that, notwithstanding their fertility, they do not seem to propagate in their native woods. We may properly ascribe this to a lesser degree of vitality in the hybrid progeny, which causes them to be crowded out in the struggle for existence." There is another reason, to us a more probable one. The hybrid tree, when isolated in cultivation, is likely to self-fertilize and so be continued in its progeny; but in its native forest, surrounded and dominated by its two parents, its female flowers will almost inevitably be fertilized by the pollen of one or the other of them and so brought back in the progeny to that species. Indeed a single tree, so situated, practically has almost no chance at all of perpetuating its kind. A. G.

2. *M. Gristave-Adolphe Thuret; Equisse Biographique;* par M. Ed. Bornet.—This is the title of an article in the latest number of the *Annales des Sciences Naturelles*, an interesting and worthy tribute by Dr. Bornet to the director and companion of his studies and researches, to whom is left the sacred duty of completing them, so far as possible. To the full biography is appended a catalogue of M. Thuret's scientific publications. The best and fullest notice of Thuret in the English language is one by Dr. Farlow, of Harvard University, contributed to Trimen's Journal of Botany at the beginning of the year. A. G.

3. *Fragmenta Phytographiæ Australiæ, contulit Liber Baro* FERDINANDUS DE MUELLER. Vol. IX. Melbourne, 1876.—This ninth volume bears testimony to the untiring industry, zeal, and ability with which Dr. Von Müller keeps up his investigations into the botany of the adopted country for which he has done so much in various ways; and his *Descriptive Notes on Papuan Plants*, and other publications upon the botany of the Pacific Islands, show how, from his vantage ground, he widens the already ample field, making the most of opportunity, ever active himself, and inciting and directing the activity and advantages of others. A. G.

4. *Flora Brasiliensis*, ed. AUG. GUIL. EICHLER.—The *Compositæ* of this great flora are undertaken by Mr. J. G. Baker of Kew, a new hand in this order, but capable of doing good work in this department, as well as among the Monocotyledons. Fascicle 62, issued in 1873, contained the *Vernoniaceæ*, with 50 plates. Fasc. 69, issued early in the present year, contains the *Eupatoriaceæ*, with 52 plates. The two fascicles compose vol. vi, part 2, with 398 pages of letterpress and 102 plates. The enlightened and active-minded emperor, Dom Pedro, may be well pleased at having such a flora of his empire, and at the prospect of its early completion. A. G.

5. *The Forest: Products of Michigan at the Centennial Exposition;* by Prof. J. W. BEAL, of the State Agricultural College.—A pamphlet of 16 pages, 8vo, giving an account, not only of the collection exhibited, but of the trees of the State, both the common and the rare species, their characteristics and their uses. There is a record of the larger trees of each species known in Michigan, which is now interesting and may hereafter become more so, if the individual trees are well identified. As to high trees: "At Clam Lake an old lumberman informed me that he could furnish spars of pine 175 feet long and not over two feet through at the butt. He had cut them 200 feet long." A. G.

6. *Contributions to the Flora of Iowa*, a catalogue of the Phænogamous plants; by G. C. ARTHUR. 1876.—A neat catalogue; with an appendix containing descriptions—generic and specific—of the species detected in Iowa which are not in Gray's Manual, twenty or so in number, and good notes upon some others. A. G.

7. *Locust invasion of* 1874.—Mr. G. M. Dawson has published a paper in the Canadian Naturalist on the Locust invasion of the country north of the United States. He remarks that they appeared in Manitoba in 1818, and from there have caused serious destruction in ten years, and been observed fifteen seasons. In 1874 none were hatched from the egg east of the 103d meridian, but in Dakota, some were hatched as far east as 99° W. The invasion in 1874 began late in June and continued during July, the direction of flight being between east and south. The most astonishing fact "is the fixed determination of the swarms to travel in a certain direction, and the wonderful instinct which leads them to a wind favoring their intention." One year they

reached the shores of the Lake of the Woods, long. 96° W. They do not eat sorghum or brown corn, and the *Leguminosæ* (pea and bean family) are decidedly disliked, while potatoes, tomatoes, and beets are usually exempt. Mr. Dawson asks whether this dislike for *Leguminosæ* may not account for the existence of a vast number of such plants on the western plains.

8. *United States Geological Survey of the Territories.* Volume X, *Monograph of the Geometrid Moths*, by A. S. PACKARD. Washington, 1876. 4to, with 13 Plates.—This is the first complete treatise on the North American species of the families of moths which Dr. Packard, following Guenée, calls *Phalænidæ.* The work is of extreme value in the present state of our knowledge of this group, for it presents us with a compilation of the literature, and from its original matter it must remain a standard of reference on the subject. Between three and four hundred species are described in the present work, while the author estimates the probable number of species occurring over our territory as "nearly a thousand." In the allied family of *Noctuidæ* we have catalogued nearly twelve hundred species, and estimate the number of species at over fifteen hundred. Dr. Packard's work is remarkable for the amount of labor expended on the generic and specific descriptions, which cannot be undervalued. The introductory chapters are of special interest, as also the concluding essay on geographical distribution. We miss an analytical table of the genera. In a work of this pretension it should not be wanting. The author finds occasion to prefer De la Guenée's work (Species Générales) to Lederer's on the moths. It is undoubted that Guenée's work on the *Phalænidæ* is superior to his work on the *Noctuidæ.* In the latter family we have found his genera largely inconsistent, and throughout important characters (e. g. the vestiture of the eyes, the armature of the tibiæ, etc.,) are totally neglected. We place his systematic work as undoubtedly lower than Lederer's, who stands at the head of all writers on the subject of genera in the two great families of the moths above mentioned. To Guenée we are disposed to give the greatest praise for his descriptions of species. Dr. Packard begins his work with the lower genera, ascending to the higher; so that the usual arrangement of the material is reversed. In the absence of a similar treatment of the other families of Lepidoptera, this change is a disadvantage to the student in arranging his collections.

In the synonymy Dr. Packard adopts the Hübnerian genera, from the Tentamen, as Mr. Scudder has done with regard to the Butterflies and we have done in the *Noctuidæ* (List of the N. Am. *Noctuidæ*, 1874). No other course is open to the systematist. Dr. Packard is fortunate in having so large material as to be able to unite several species hitherto regarded as distinct (e. g. the species of *Drepanodes* and *Ellopia*); with regard to the species of *Ellopia* Dr. Packard says: "If I had had Mr. Grote's types alone of male *E. bibularia* and female *pellucidaria*, I should have regarded them as distinct." Perhaps in uniting *Endropia amœnaria* and *E. arefuctaria* Dr. Packard may prove less fortunate. In the generic names adopted we find a few which will not stand. *Eu-*

gonia is preoccupied in the Butterflies. *Eutrapela* must be used for *Kentaria* and *Alciphearia; Chœrodes* for the genus called *Eutrapela* by Dr. Packard. The plates are worthy of great praise, and will bear the most critical inspection. The numerous general figures were drawn on stone by Trouvelot. Dr. Hayden is to be heartily congratulated on the publication of this volume, which reflects much credit upon his judgment and the scientific standing of the Geological Survey, and Dr. Packard deserves the gratitude of entomologists for his treatment of the subject. A. R. G.

9. *Tabulate Corals.*—Dr. G. Lindström, in a paper a translation of which is given in the Ann. Mag. Nat. Hist. for July, discusses with judgment the relations of the tabulated corals. He refers the *Millepora* to the Hydroids (adopting Agassiz's conclusion); *Favosites* to the Poritinæ (following Verrill) with *Rœmena*, *Striatopora* Hall, etc.; *Heliolites*, *Halysites*, *Lyellia* E. & H., *Plasmopora* (with *Propora*) E. & H.; *Calapœcia* Billings, *Thecostegites* E. & H., to the Heliolitidæ; *Heliopora* and *Polytremacis* to the Alcyonaria; *Chætetes*, *Monticulipora*, *Dania*, *Stellipora*, *Alveolites* in part, *Fistulipora* in part, to the Bryozoa: *Pocillopora* (following Verrill) to the Oculinidæ, with, probably *Seriatopora; Columnaria*, to the Cyathopyllidæ; *Fletcheria* and *Michelinia* to the Cystiphyllidæ; *Syringopora*, to the vicinity of Lithostrotion and Diphyphyllum.

10. *Rafinesque's Ichthyologia Ohiensis.*—Dr. D. S. JORDAN has a paper giving the equivalents in modern nomenclature, so far as were ascertainable, of the species of fishes named by Rafinesque, in the Bulletin No. 3 of vol. iii of the Buffalo Society of Natural Sciences. The same number contains also a check-list of the fishes of the freshwaters of N. America by Dr. Jordan and H. E. Copeland. and a synonymic list of the Butterflies of N. America, north of Mexico, by S. H. Scudder.

11. *Synopsis of American Wasps;* by HENRI DE SAUSSURE of Geneva, Switzerland. *Solitary Wasps.* Smithsonian Miscellaneous Collections, No. 254. 386 pp. 8vo, with 4 plates. Washington, December, 1875.

12. T. LYMAN, *on Ophiuridæ and Astrophytidæ* collected by the Hassler Expedition and Dr. Wm. Stimpson. Illustrated Catalogue of the Mus. Comp. Zool. at Harvard College. No. VIII. 34 pp. 4to, with five excellent plates.

13. *Bulletin of the U. S. National Museum, published under the direction of the Smithsonian Institution*, No. 4. Birds of Southwestern Mexico, collected by F. E. Sumichrast, prepared by G. N. Lawrence. 56 pp. 8vo.—No. 5. Catalogue of the Fishes of the Bermudas, by G. Brown Goode. 82 pp. 8vo. Washington, 1876.

Catalogue of the Stalk- and Sessile-Eyed Crustacea of New Zealand, by Edward J. Miers, F.L.S., Assist. Zool. Dept. Brit. Mus., Colonial Museum and Geological Survey Department, James Hector, M.D., Director. 136 pp. 8vo, with 3 plates. London, 1876.

Catalogue of the Birds of Kansas, by F. H. Snow. 3d ed. 14 pp. 8vo. Nov., 1875.

List of Skeletons and Crania in the Section of Comparative Anatomy of the U. S. Army Medical Museum.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On Oceanic Circulation;* by WM. B. CARPENTER.—The very decided expression of opinion on the part of Professor Wyville Thomson, to which currency is given in the *Athenæum*, against the doctrine of "a general vertical circulation of the water of the ocean, depending on differences of specific gravity," is far from being decisive of the question; and might, perhaps, have been advantageously withheld, until my friend should have learned, on his return home, what progress has been made towards its solution by physical inquiry, during his three and a half years' absence.

If he had been present at the Bristol meeting of the British Association, he would have learned, from Mr. Froude's experimental confirmation of the "wave-line theory" of our greatest mathematical physicists, that *friction of water upon water* is so small an obstacle to its movement, that it may be practically disregarded; so that very small disturbances of the static equilibrium of ocean water—whether produced by diversities of temperature, or by alterations of its salinity—*must* give rise to a movement tending to its restoration, without the necessity of any appreciable "gradient." And he might have further received from Mr. Froude (as I had the advantage of doing) the confirmatory evidence on this point furnished by his extended observations on harbors, lochs, and fiords; to the effect that wherever the specific gravity of the surface-water of any such inlet of the sea is reduced by a river efflux, an under-current of sea-water is forced inwards by the excess of pressure outside. At the same meeting, my friend would have heard Sir William Thomson, commenting upon Mr. Croll's asserted disproof of the "gravitation theory," give the full weight of his great authority to the doctrine (originally propounded by Lenz in 1845) of a vertical oceanic circulation sustained by opposition of temperature; Sir William emphatically declaring it to be a matter "not of opinion, but of irrefragable demonstration."

If, again, Prof. Wyville Thomson had enjoyed the advantage of meeting the distinguished foreign physicists, Prof. Möhn, of Christiania, and Prof. Buys Ballot, of Utrecht, who recently came over to attend the Meteorological Congress in London, he would have found them entirely satisfied of the truth of the gravitation doctrine; and would have received from the former the following remarkable exemplification of it:—

Outside the coast of Norway, there is a deep channel, along which a flow of glacial water can be traced southward as far as the Cattegat. This flow cannot possibly be accounted for by any "excess of evaporation over precipitation;" for it proceeds towards an area that receives a large river efflux from the Christiania fiord, as well as the efflux of weakly-saline water from the Baltic. And it is unhesitatingly attributed by Prof. Möhn to the relative excess of downward pressure over the northern end of the trough, constantly maintained by the reduction of downward pressure over its southern extremity, which results from the admixture of fresh water.

Until, therefore, Prof. Wyville Thomson shall have been able to disprove these results of combined theoretical and practical research, by showing that differences of specific gravity, produced by differences either of temperature or of salinity, will *not* produce movements in oceanic water tending to the restoration of its disturbed equilibrium, I venture to affirm that his *dictum* will not find acceptance with the physicists who have most carefully studied the question. His present doctrine, that the underflow of polar water is an indraught due to "the excess of evaporation over precipitation," is as much opposed to physical theory as his former doctrine that the indraught is due to the sweeping away of equatorial water by the trade winds, which was unhesitatingly pronounced untenable by the distinguished physicists who discussed it at the last Edinburgh meeting of the British Association. For they were unanimous in affirming that a removal of surface-water from any area will be replaced by a surface inflow (where this is unrestricted), rather than by an indraught from beneath. And it seems to me no less in contradiction to the facts of the case. For the Challenger observations have afforded the fullest confirmation of the two fundamental positions of Lenz's doctrine:—(1) The near approach of polar water to the surface under the equator; and (2) The marked inferiority in the salinity of equatorial surface-water as compared with that of the tropics. The first of these facts shows that the updraught of polar water is nowhere so strong as it is under the equator; the second proves that, in some way or other, the loss by evaporation in the equatorial area is more than replaced, so that it can occasion no such updraught.

These two facts were considered, by one of the ablest physicists of his time, as capable of no other explanation than that afforded by the doctrine of a vertical oceanic circulation, of which the *primum mobile* is the excess in the specific gravity of polar water, causing its continual descent and a complemental ascent in the equatorial zone.

I am far from affirming that "excess of evaporation over precipitation" has no influence in producing movements of ocean water; on the contrary, I have shown that it is the *vera causa*, not only of the surface in-current, but of the outward under-current, of the Gilbraltar Strait. And it is, doubtless, one of the agencies at work, whenever it operates strongly over a localized area.

The problem of Oceanic Circulation, in fact, is rendered one of great complexity by the number of such agencies, and the great variety in the local conditions under which they respectively operate. And since, in the discussion of the vast body of valuable observations collected by the Challenger, it will be of the first importance that the principles on which that discussion is to be based should be settled by the highest authorities in physical science, I trust that at the ensuing meeting of the British Association at Glasgow, an opportunity may be provided for a full and free debate, in which Prof. Wyville Thomson, Mr. Croll, and I, may set forth our respective views in friendly antagonism, and

may submit them to the judgment of the distinguished physicists who will doubtless be there assembled.

To such a judgment I pledge myself implicitly to bow; no one being better aware than myself of the disadvantage under which I labor in possessing no more than an elementary knowledge of physical doctrine.—*Athenæum*, May 13.

2. *Reclamation.*—*Letter to the Editors, from Mr. George Davidson, U. S. Coast Survey*, dated San Francisco, March 7, 1876.—In the March number of your Journal (No. 63, vol. xi,) Article xxix, by Professor Lovering, the statement is made that "the late Professor Winlock [in February and March, 1869] sent electrical signals from Cambridge to San Francisco, and thence by other lines to Canada, and back again to Cambridge, over a loop of wire measuring 7200 miles."

Professor Winlock and I were always in full accord in this and other matters, and I am sure he never made the above claim. On the contrary, he gave me full credit for the inception of the experiments, and the successful determination of the wave time over a loop of wire of 7200 miles with the batteries and repeaters in line. The experiment was a necessary consequence of the telegraphic longitude operations of the United States Coast Survey between Cambridge and San Francisco.

Moreover, the experiment was not made at Cambridge; it was made by me in the Coast Survey Observatory at San Francisco, and the loop was made by Professor Winlock at Cambridge. The signals were transmitted from my clock to Cambridge, and to other stations and back; and as Cambridge did not have the necessary instrument for such a record, Professor Winlock devised a means of sending and receiving clock signals over a single wire; unfortunately the cable across the Golden Gate broke after passing the first series, and no more were undertaken.

The whole work is fully detailed in the records of the Coast Survey, and, by permission of the Superintendent, the results and *modus operandi* were verbally communicated by me to the California Academy of Sciences.

If, however, the details of my work and of Professor Winlock's device are of any interest to experimentalists, I can readily supply them from the original memoranda.

3. *Men of Science, from abroad, at the U. S. International Exhibition.*—No occasion has before drawn together so many distinguished men of science from abroad, in various departments, as the Centennial Exhibition at Philadelphia. Without attempting to enumerate all whose names might properly be mentioned in this relation, we recall, from Great Britain, Sir WILLIAM THOMSON, the well-known physicist who is President of the Judges on the XXVth Group—Instruments of Precision and Research; Sir JOHN HAWKSHAW, the eminent engineer who was last year President of the British Association; Sir CHARLES REED, President of the XXVIIIth Group of Judges—for Education and Science; Capt. DOUGLAS GALTON, President of the Judges under the XVIIIth Group—Railway Plans, etc.; Mr. ISAAC LOWTHIAN BELL, the

most eminent iron metallurgist in Great Britain, and author of the well-known treatise on the 'Chemistry of the Blast Furnace,' President of the Judges of Group I—Minerals, Mining, Metallurgy, etc.; Dr. WILLIAM ODLING, Waynflete Professor of Chemistry in the University of Oxford, Secretary of the board of Judges on Group III—Chemistry and Pharmacy, etc.; from Sweden, Prof. ADOLF E. NORDENSKIÖLD, Prof. C. A. ANGSTRÖM, Polytechnic Institute, Prof. O. M. TORELL, Chief of the Geological Survey of Sweden, and RICHARD ÅKERMAN, of the Royal Swedish School of Mines, all from Stockholm, under whose immediate superintendence the excellent geological, mineralogical, and metallurgical display of Sweden, at the Exposition, has been made; from Russia, Major General AXEL GADOLINE, an eminent Russian engineer, and Prof. L. NICHOLSKY, Mining Engineer and adjunct Professor at the Mining School of St. Petersburg, who is in charge of a systematic collection of Russian minerals—the only systematic mineral collection in the Exposition; from Germany, Dr. WEDDING, Royal Prussian Counsellor of Mines, Dr. RUDOLPH VON WAGNER, the well-known Editor of Wagner's Jahresbericht, and Dr. G. SEELHORST, of Nuremberg; from France, Mr. L. SIMONIN, J. F. KUHLMAN (fils), M. E. LEVASSEUR, and M. EMILE GUIMET, of Lyons; from Italy, Prof. EMANUEL PATERNO, of Palermo; from Mexico, MARIANO BARCENA, the mineralogist.

The Emperor of Brazil, without claiming the position of a man of science, manifests the most intelligent and cultivated understanding of all that is most worthy of notice in scientific methods, his enquiries extending to everything which should interest the Head of a great Continental Empire.

Prof. Nordenskiöld on July 1st, left on his return, to join a new expedition of discovery to the seas of Northern Siberia.

4. *Connection of the Caspian and Black Seas.*—It is reported that the connection of the Caspian and Black Seas by a canal, and a raising thereby of the surface of the Caspian—now below sea-level—is under consideration. The length of the proposed canal would be 240 kilometers, and the width to the eastward about 170 yards, and to the westward about 110 yards. A second project, complementary to this, is the junction of the Don and Volga, and the turning thus into the Caspian of the larger part, if not the whole of the former river. The project has been proposed to the Russian Government by an American company.—*L'Institut*, 28 *Juin.*

5. *Geographical Survey of the State of New York.*—The board appointed by the act of the last Legislature to make a trigonometrical survey of the State, have adopted resolutions to the effect that an officer shall be appointed, with the title of Director, whose duty it shall be to prepare and submit to the consideration of the Commission plans for conducting the survey, with estimates thereof, and under the direction of this board to organize, superintend, and manage the work required for carrying out such of these plans as shall be approved; that the Director shall nominate suitable assistants for the required duties of the survey, and that none shall be appointed unless nominated by him; that the Di-

rector and all other officers shall hold office during the pleasure of the board; that the salary of the Director shall be $4,000 per annum, including expenses. Under the first resolution the board proceeded to choose a Director, and Prof. James T. Gardner, at present Secretary of the American Geographical Society, was elected.—*N. Y. Times*, July 13.

6. *Appalachia*, June, 1876, vol. I, No. 1, 62 pp. 8vo. Boston: A. Williams & Co. Published for the Appalachian Mountain Club.—The Appalachian Mountain Club was organized in 1876 "for the advancement of the interests of those who visit the Mountains of New England and adjacent regions, whether for the purpose of scientific research or summer recreation." The Club proposes to carry on a systematic exploration of the regions referred to, both topographical, geological, and artistic. The President is Prof. E. C. Pickering, Vice President S. H. Scudder, and Secretary J. B. Henck, Jr., of the Technological Institute, Boston. The papers contained in this first number of the publications of the Club, are a Report on the Nomenclature of the White Mountains; an abstract of a paper on the "Atlantic System of Mountains," by C. H. HITCHCOCK; a day on Tripyramid, by C. E. FAY; on two new forms of Mountain Barometer, by S. W. HOLMAN; a new map of the White Mountains (with a Map) by Mr. J. B. HENCK, Jr.; on the East Branch of the Pemigewasset, by W. UPHAM; together with reports of the Councillors for the spring of 1876, containing suggestions of work proposed for the summer.

7. *American Association for the Advancement of Science.*—The 25th meeting will commence at Buffalo, N. Y., August 23. Members on arrival will find the Permanent Secretary at the Tifft House. By means of certificates, obtainable of the Permanent Secretary, at Salem, Mass., tickets at reduced prices may be had on the following railroads: Erie, Grand Trunk, Canada Southern, Great Western, Pennsylvania, Lake Shore and Michigan Southern, Cleveland, Columbus, Cincinnati and Indianapolis, New Orleans, St. Louis and Chicago.

8. *Elements of Physical Geography*, for the use of Schools, Academies and Colleges; by EDWIN J. HOUSTON, A.M., Prof. Phys. Geog., and Nat. Phil., Central High School, Philadelphia. 158 pp. sm. 4to, with many illustrations. Philadelphia, 1876. (Eldredge & Brother.)—An excellent text book well adapted for school instruction. The numerous illustrations are beautiful and include several colored maps.

9. *Proceedings of the Poughkeepsie Society of Natural Science*, vol. i. 42 pp. 4to.—This first number is occupied with an article giving the views of Mr. CHARLES B. WARRING, in an article entitled "Studies upon the Inclination of the Earth's Axis."

10. *Transactions of the Kansas Academy of Science*, vol. iv. 62 pp. 8vo. Topeka, 1875.—This volume contains papers by Prof. W. K. Kedzie, on ozone in the Kansas atmosphere, and on the Nebraska hot bluff (hot through the oxydation of pyrite); G. E. Patrick, on the Kansas chalk, analysis of Kansas soils, and on Kansas salt; M. V. B. Knox, on Kansas Mammalia; G. F.

Gaumer, on the habits of some larves; W. Osburn, on the Cotton-wood leaf-beetle; F. H. Snow, on the Rocky Mountain Locust, the larve and chrysalis of the Sage Sphinx, Catalogue of the Lepidoptera of E. Kansas (503 species), and Meteorological Summary for 1875. The meteorological summary states that the amount of rain (including snow) at Lawrence, Kansas (38° 58′ N., 95° 16′ W., at an elevation above the sea-level of 884 feet) was 28·87 inches, the same as for 1874, but 4·11 inches below the average rainfall of the last eight years.

11. *hkl.*—A new mineralogical society has been formed in England, styled the *hkl*, having Prof. Miller as its President.

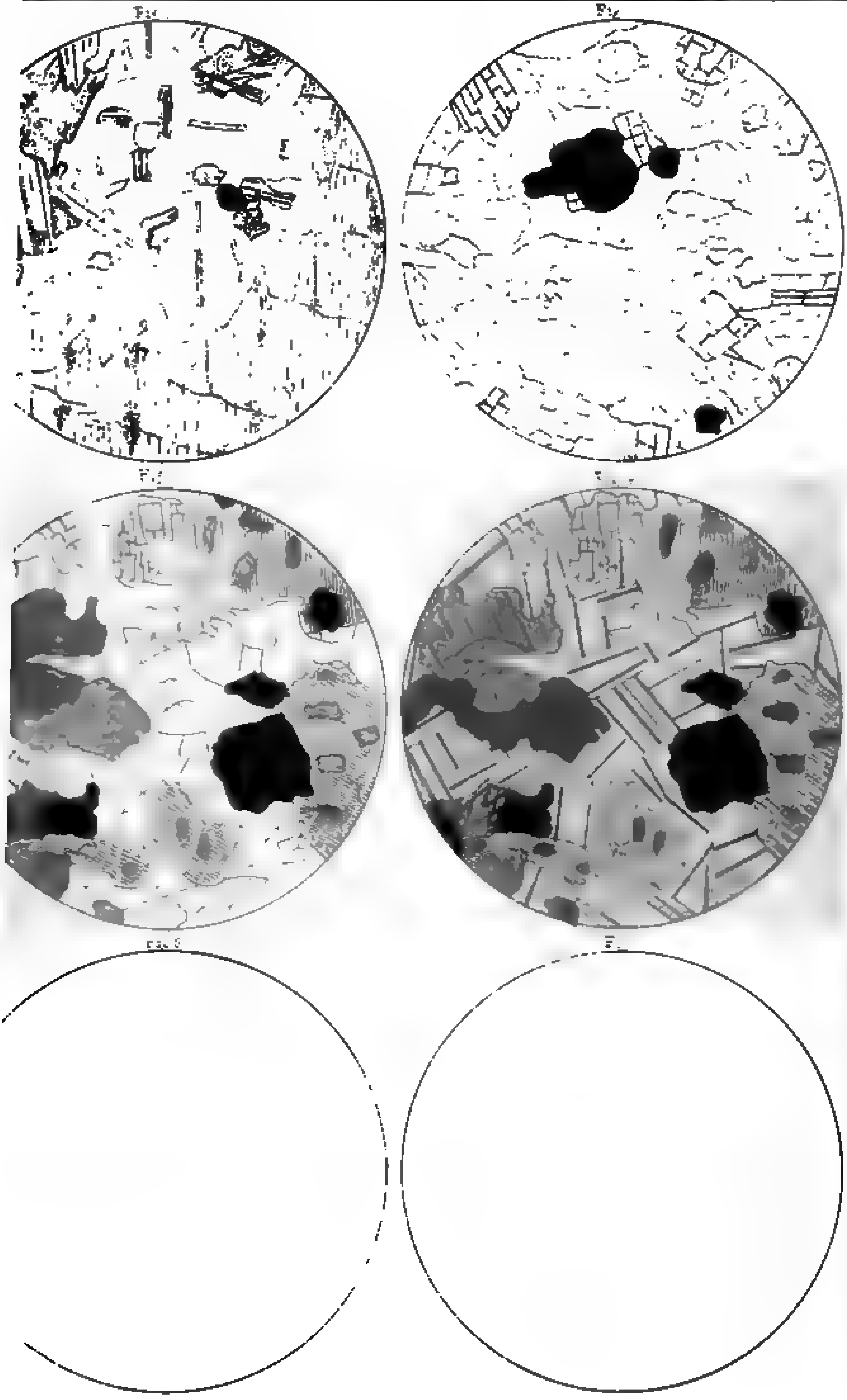
Medical Statistics of the Provost Marshal General's Bureau. Compiled under the direction of the Secretary of War, by J. H. Baxter, A.M., M.D. Vols. I. and II. Thick 4to. 1875.

Principia or Basis of Social Science; by R. J. Wright. Second Edition. 542 pp. 8vo. Philadelphia, 1876. (J. B. Lippincott & Co.)

OBITUARY.

Porter Poinier, only son of Elisha B. and Frances A. Poinier, of Newark, died in New York city on Sunday afternoon, June 11th, aged 23 years. He had given himself to the study of Physics, and in the Polytechnic Institutes of Troy and Hoboken, he had thus early developed a very remarkable genius in the department of applied science. His studies had led him, with great success, into original investigations of heat as a force in nature, and his thorough and accurate and independent researches in this direction had attracted the favorable notice of the faculties under whom he studied. He attained to such important results as were found worthy of public notice, and he was engaged in the preparation and publication of an original work on the Dynamics of Heat, with the approval of his professors. His enthusiasm drank up his spirits, and utterly exhausted his physical force. Before he was aware, he was in the advanced stages of an incurable disease, and, while laboring to put his work through the press at Cambridge, he was pronounced beyond recovery. All his ardor in study was suddenly quenched by disease, and sadly he fell in the midst of his successes.

His very rare attainments and his extraordinary promise in the field of research had been brought to the notice of the Johns Hopkins University at Baltimore, and the day after his death, only too late for his noble ambition, came the certificate from the heads of the University, appointing him to a Fellowship in that institution. As a lecturer in the department of his special and successful study he had become familiar with the best French and German works in modern science, and his accuracy and perseverance and thirst for knowledge gave him promise of a very eminent future as a scientist. Such a young man, of unblemished morals, of pure and lofty aims, gifted with faculties of so high order, already attracting the attention of the learned, and laying down his life for truth as revealed in God's Book of Nature, trained, withal, to the highest of sciences in the written revelations, and searching for the truth of Christ, such a young man fills a large space and dies leaving a sad void. J.



THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXI.—*On the Gases contained in Meteorites.* Second paper; by ARTHUR W. WRIGHT, Yale College.

IN a previous article, published in this Journal, April, 1876, the writer gave the results of investigations upon the nature of the gases evolved from a number of meteorites of both the iron and the stony classes, when exposed to a more or less elevated temperature. The stony meteorites examined were all of the more common type, containing a considerable percentage of nickeliferous iron, without any appreciable quantity of uncombined carbon. As is well known, however, among these bodies of the stony kind, the meteorites of Alais, Kold Bokkeveld, Kaba, and Orgueil, form a distinct class, differing from the rest in several particulars, and especially in containing considerable proportions of amorphous carbon, and a bituminous substance consisting of carbon combined with oxygen and hydrogen in such a way as to simulate organic products. They are further distinguished by containing only very small quantities of metallic iron. As it seemed of interest to determine whether the conclusions arrived at in the investigations previously described were applicable to the bodies of this peculiar class also, the work was continued, with the results given below. Several other points of importance, referred to in the previous paper, were investigated, and are discussed in subsequent paragraphs.

The material used for the determinations was a fragment of an excellent specimen of the Kold Bokkeveld meteorite in the cabinet of Yale College. It contains an inconsiderable propor-

tion of metallic iron, though this is not entirely absent, for, on filing away the surface, very minute particles may occasionally be seen. The analysis made by Harris* gives for the carbon 1·67 per cent, and for bituminous matters 0·25 per cent. As has been shown by Professor J. L. Smith,† the mineral constituents are not greatly different from those of the ordinary stony meteorites. The method employed for the evolution and collection of the gases was essentially the same as that described in previous papers, and need not be given in detail here. It is sufficient to mention that, as the meteorite gives off a large amount of water on being heated, the tube containing the substance was connected with the pump by a recurved tube, the bend of which was placed in a freezing mixture during the evolution of the gas, in order to collect the water and prevent it from entering the pump. This tube was sealed with a gas flame at the close of the experiment and the water retained for examination. The temperatures employed for driving off the gaseous contents were nearly the same as those of the previous experiments, being however slightly lower, in order to avoid as far as possible complication of the results by the action of the heat upon the bituminous matter. The results were as follows:

Kold Bokkeveld.

	CO_2.	CO.	CH_4.	H.	N.	Volumes.
300°–350°	87·34	5·08	5·93	trace?	1·65	7·45
500°	95·53	1·32	2·14	0·54?	0·47	17·78
Total.	93·11	2·42	3·25	0·38?	0·84	25·23

The volume of the gases obtained is much greater in this than in the previous determinations; but it will be seen that in its composition the gaseous mixture is similar to that derived from the ordinary stony meteorites, with the exception of the hydrogen, of which, if any was present, the quantity was so small as to make its determination a matter of some uncertainty. The percentage of carbon di-oxide is somewhat larger at the higher temperature than in the other cases, but the real difference here is less than it appears, as the increase in the quantity of hydrogen evolved at the higher temperatures from the specimens which contained metallic iron, produced a corresponding diminution in the percentage of the carbon di-oxide; neglecting this, the proportions would show a much closer correspondence. It seemed probable that, at least at the higher temperature, an appreciable quantity of some hydrocarbon of the olefiant series, that is, with more carbon atoms than are contained in marsh-gas, might be found. But both the analyses, and special tests

* C. Rammelsberg, Die chemische Natur der Meteoriten. Abhandl. der Königl. Akad. zu Berlin, 1870.

† This Journal, III, xi, p. 391.

of the gas with fuming sulphuric acid, showed that the quantity of such substances possibly present was too small to carry it beyond the range of the ordinary errors of observation. The bituminous substance would thus appear to have been simply volatilized by the degree of heat employed, and condensed again in the cooling-tube without decomposition. No attempt was made to collect it separately.

The amount of water driven off by the heat and collected in the cooled tube was found to be about ten per cent of the weight of the substance employed, but the determination was not entirely satisfactory. Faraday found for the water 6·5 per cent. Wöhler states that the powder dried at 120° lost 10·5 per cent more by stronger heat. Rammelsberg found that the total loss at a strong heat was 15·24 per cent, but this of course includes, besides the water, the gases evolved and the volatile bituminous substance, as well as some sulphur, which was observed to be volatilized. The water, on the application of the ordinary tests, gave distinct evidence of the presence of chlorine, and less certainly of sulphurous oxide, resembling in these respects that derived from other meteorites. A small quantity of a light yellowish substance was deposited in the cold part of the tube, which appeared to be sulphur, but was not specially examined.

The differences in the gaseous products obtained from meteorites of the different classes may be made more apparent by bringing together the results of analyses hitherto made. The following table gives the total percentage of the gases yielded by the different specimens, the first seven being irons, the remainder belonging to the stony class. It represents the composition of the total amount of gas given off up to incipient or low red heat, except in the first two instances where the temperature employed was much higher.

Iron meteorites.	CO_2.	CO.	CH_4.	H.	N.	Vol.	Observers.
Lenarto,	4·46	0·00	...	85·68	9·86	2·85	Graham.
Augusta Co., Va.,	9·75	3[illegible]·33	...	35·83	16·09	3·17	Mallet.
Tazewell Co., Tenn.,	14·40	41·23	...	42·66	1·71	3·17	W.
Shingle Spr., Cal.,	13·64	12·47	...	68·81	5·08	0·97	W.
Texas,	8·59	14·62	...	76·79	0·00 ?	1·29	W.
Dickson Co., Tenn.,	13·30	15·30	...	71·40	0·00 ?	2·20	W.
Arva,	12·56	67·71	...	18·19	1·54	47·13	W.
Stony meteorites.							
Iowa Co.,	49·51	2·64	0·0 ?	43·93	3·92	2·50	W.
Guernsey Co., Ohio,	59·88	4·40	2·05	31·89	1·78	2·99	W.
Pultusk,	60·29	4·35	3·61	29·50	2·25	1·75	W.
Parnallee,	81·02	1·74	2·08	13·59	1·57	2·63	W.
Weston,	80·78	2·20	1·63	13·06	2·33	3·49	W.
Kold Bokkeveld,	93·11	2·42	3·25	0·38 ?	0·84	25·23	W.

In the case of the last of these meteorites the number given in the table does not express the whole volume of gas contained in it, as the experiment was discontinued before it ceased to be given off. A special determination made with a separate portion gave a little more than thirty volumes. The Arva meteorite also is exceptional, both as regards the volume of gas yielded by it, and with respect to the large volume of the carbonic oxide obtained. We are reminded, by this fact, of the Ovifak iron, from which Wöhler obtained, by heating it to redness in an iron tube, more than 100 volumes of gas which was found to be carbonic oxide mingled with a little carbon di-oxide.* He attributes it, however, to the action of the carbon upon some oxygen compound, and the mass was found to contain a large quantity of magnetic oxide of iron. Doubtless the result was affected by the employment of the iron tube, which would rapidly reduce the carbon di-oxide at such a temperature. Berthelot, who examined another portion, at M. Daubreé's request, obtained by slow calcination in a tube of Bohemian glass a large volume of gas, the precise amount of which is not stated, consisting chiefly of the two oxides of carbon in nearly equal quantities.† The celestial origin of the Ovifak iron is very doubtful, however, and its composition is different from that of the Arva meteorite, in which no oxygen compounds were detected.

A few words need to be said with reference to the volumes quoted in the case of the Tennessee, Texas, and Arva irons. In an article published in this Journal, for April, 1875, giving an account of a spectroscopic examination of the gases from these bodies, it was stated that the volumes were as follows: Tennessee, 4·69; Texas, 4·75; Arva, 44+, whereas the volumes as determined in the subsequent investigations by actual measurement were 3·17, 1·29, and 47·13, respectively, as given in the table. The discrepancy is due to the fact that the former numbers were calculated from the change in the reading of the gauge of the air-pump on evolution of the gas, and were not corrected for the small amount of water vapor present. Where the quantity of gas was small the error from this source was considerable, and the result would have only the value of a rough estimate. In the case of the Arva iron, where the volume of the gas was much larger, the inaccuracy was not serious, and the volume corresponds much more nearly with the true result as obtained from measurement. In the later determination of the volume of gas from the Texas iron, moreover, the metal was in rather coarse fragments, and the evolution of gas from it was not as complete as in the previous case. That the amount of gas obtainable from this iron

* Pogg. Ann. 146, p. 297. † Comptes Rendus, lxxiv, 1545.

should approximate to that obtained from the Tennessee specimen, if the trial were made with finely pulverized metal, is clearly indicated by the results of the earlier experiments.

The necessity for the precautions mentioned in the previous paper respecting the degree of heat employed and the time of its application, was well shown in the repetition of the experiments with the Iowa meteorite. The reducing action of the metallic iron upon the carbon di-oxide, though not very apparent at comparatively moderate temperatures, becomes considerable as the temperature rises, and in some of the experiments where the heat was carried nearly to redness and prolonged beyond what was necessary for the evolution of the larger part of the gas, it was found that the amount of carbonic oxide was very variable, in one instance reaching to 12 or 13 per cent. This explains also the larger amount of this gas obtained in the preliminary examination of last year where the analysis gave 14 per cent, as no special attention was at that time given to this source of error. It is also clearly shown by the following experiment with a portion of the Weston meteorite. After the gas had been driven off from this by a red heat, pure, dry carbon di-oxide was admitted into the pump, and the tube heated nearly to redness for about half an hour. On pumping out some of the gas and analyzing it, it was found that nearly twenty per cent of it had been converted into carbonic oxide. Although great care was taken in all the subsequent work to avoid this source of inaccuracy as completely as possible, the percentages of this gas obtained at the higher temperatures are less certainly to be depended upon than the others. The amount of marsh-gas obtained also shows a certain correspondence with that of the carbonic oxide, as if, possibly, in the reaction by which the carbon di-oxide was broken up by the iron, a portion of the carbon combined with the hydrogen present to form marsh-gas, a supposition which is not without warrant from the conclusions of other observers.* But though some degree of uncertainty may attach to the numbers given for the higher temperatures, the fact that, with all the precautions observed in the experiments, the gases were found to be present in small quantities even at the lowest temperatures at which examination was made, renders it probable that the results are not far from the truth, and that carbonic oxide and marsh-gas are really to be reckoned among the gaseous contents of the stony meteorites, and that the same cause which produced the one in greater or less quantity had a similar effect upon the other.

Among the questions discussed in the previous paper, was the manner of the occurrence of the carbon di-oxide. This has

* Watts's Dict. of Chem.

been subjected to further examination, with the result of modifying somewhat the conclusions there arrived at. That it has been derived from the atmosphere by absorption subsequently to the fall of the body is improbable, for not only did the re-examination of the Iowa meteorite show a loss rather than gain with the lapse of time, but also there would seem to be little reason for a selective action of the mass, which would enable it to take up this gas in preference to the other atmospheric constituents, unless it were the fact of the feebly acid character of the carbon di-oxide, as in the presence of, or combined with, water. But in this case the carbonates formed by combination with the oxides present in meteoric masses, would be very stable compounds, and quite incapable of decomposition at the low temperatures employed.

The explanation was suggested in the earlier papers that the gas was condensed upon the finer particles of the metallic iron, as well as absorbed within it. With a view to test the correctness of this supposition, a special set of experiments was undertaken. A quantity of the substance of the Iowa meteorite was reduced to fine powder, and the iron extracted from it with a magnet, and kept by itself. The grains of iron were then rubbed repeatedly in an agate mortar to free them as completely as possible from the adhering stone, from which they were separated as before, the residue of the powder being added to that left by the first operations. The material was thus divided into two portions, one of which consisted chiefly of the stony matter, the other principally of the iron. For a third portion pieces of the meteorite were simply broken into small fragments, and not pulverized. Each portion was placed in a clean tube, and in its turn attached to the pump for examination, care being taken to subject each, as nearly as was possible, to the same degree of heat, and for the same length of time. The highest temperature employed was below that of red heat. The following were the results obtained:

	CO_2 and CO.	H.	N.		Volumes.
Powder,	66·96	30·96	2·08	0·97	1·48
Iron,	38·72	59·38	1·90	0·51	
Fragments,	48·07	50·93	1·00		1·87

Although, from the nature of the case, no very precise result could be expected from this mode of experiment, inasmuch as it was impossible either to separate the iron entirely from the mineral portion, or to free the iron completely from the stony matrix, the numbers above given indicate clearly that the stony portion yields a considerable portion of the gas given off at the temperature employed, and that this contains a larger proportion of the carbon oxides than that obtained from the iron, which, on the other hand, is richer in hydrogen. The product

of the stony fragments is, in its composition, approximately a mean between the two others, as was to be expected, but it will be seen that the volume obtained was somewhat larger, showing that a portion of the gas was lost in the process of pulverization. These facts would seem to indicate that, while a portion of the gas may be condensed upon the fine particles of the iron as at first conjectured, a large part of the carbon di-oxide, and possibly also of the water, carbonic oxide, and other gases, is mechanically imprisoned in the substance of the meteorite. Now Mr. Sorby has shown* that the meteorites of Aussun and Parnallee, when examined in thin sections under the microscope, contain numerous small cavities filled with gas, similar to those which have been observed in many terrestrial minerals It will be noticed that the Parnallee meteorite was one of those examined by the writer, and found to yield 2·63 volumes of gas on the application of heat.

The occurrence of carbon di-oxide in cavities of minerals, under a pressure so great as to cause it to be in the liquid condition, as also associated with water, has been often observed, and has been quite recently proved in an ingenious and satisfactory manner, by Mr. Hartley,† for a large number of different minerals. Similar gas-cavities have been shown also to exist in many eruptive or volcanic rocks, for examples of which we need only to refer to Mr. Sorby's and Mr. J. C. Ward's papers in the Quarterly Journal of the Geological Society, and to other memoirs published elsewhere. The actual extraction and chemical examination of the gaseous contents of these bodies appears to have attracted little attention thus far, though they might lead to results of great interest and importance. Some incomplete experiments by the writer may be mentioned here, as illustrations, though but little weight is attached to them as quantitative determinations. A quantity of pulverized trap-rock was subjected to a heat which was raised to incipient redness, the examination being conducted by the same method as that employed upon the meteorites. The mineral gave off about three-fourths of its volume of mixed gases, which were found to contain about 13 per cent of carbon di-oxide, the residue being chiefly hydrogen. Another specimen of trap containing small nodules of anorthite, was examined, at the request of Mr. G. W. Hawes, who had observed gas-cavities in a thin section of the mineral prepared for microscopic examination. This gave off somewhat more than its own volume of gas, which was found to contain some 24 per cent of carbon di-oxide. The gas in these cases was not given off as readily as from the meteorites, and was evolved rather suddenly as a temperature approaching red-heat was reached. If it should appear improbable that the large

* Proc. Royal Soc., June 16, 1864.
† Chem. News, June 9, 1876, p. 237.

amount of gas contained in the Kold Bokkeveld specimen could be retained in this way, it may be suggested that the amorphous carbon contained in it is a substance peculiarly fitted to absorb and retain large volumes of gas. These results would seem rather to assimilate the stony meteorites to terrestrial rocks of volcanic origin, than to place them in a different category, and to strengthen the evidence that they are themselves the product of igneous action, though modified profoundly in some respects in their structure, by the influence of other forces, and the circumstances of their formation. The supposition of the imprisonment of the gas in the stony substance would also serve to explain why the water, which can not be separated by a temperature of 100°, continues to be given off even at the highest temperatures employed, as has often been observed in experiments with meteorites.

It has been pointed out by astronomers that on arranging the mean distances of the asteroids in a series, there are found to be certain gaps in the list, as if some members were wanting. Now it is further found that the periodic times of these missing bodies stand in a simple relation to the time of Jupiter's revolution, and in such a way that his continued action upon them would accumulate the perturbative effects, tending to throw their orbits into eccentric forms. Such of the bodies as were caused to move in very narrow orbits, with shortened period, would be exposed to very great vicissitudes of temperature, and during the part of the orbit near the sun not only would the change of temperature be comparatively rapid but the actual degree of temperature reached would be very considerable, especially considering the fact that these bodies are of too small mass to permit them to retain an atmosphere of any appreciable amount. It is not difficult to see that these great changes of temperature in a mass of considerable absorptive and low conducting power must give rise to powerful stresses, and that under the intense action of the sun near the perihelion the action may be sufficiently energetic to cause the splitting up of the bodies themselves. The disruptive action requisite to separate a mass from the principal body entirely, and so as not to return, would be less as the mass of the body is smaller, and would, for a mass no larger than some of the asteroids, be quite within the range of possibility. The body would thus be subject to a continuous process of disintegration in its successive revolutions, and must end in being broken up into a swarm of fragments which would gradually be distributed over the entire orbit. Such an action appears to be really going on in some of the comets, and moreover the orbits of several of them are coincident with those of great meteoric streams, in which the process of disaggregation has already gone very far. Now, of the comets of short period a considerable number are grouped

with their orbits in such a relation to that of Jupiter as to suggest the possibility of their derivation from the asteroids. Similar considerations also apply to the group of comets associated with the orbit of Neptune, the existence of which suggests the question whether there may not be another group of asteroids, exterior to this body, yet remaining to be discovered. But without assuming the asteroidal origin of these comets, the effects of solar heat just described may be safely predicated of them, as well as of other comets or meteoric masses revolving in excentric orbits.

This process of disintegration, in the earlier stages of the history of one of these bodies, would constantly present fresh surfaces for the action of the sun's rays, which must cause the evolution of large volumes of gas, and the rifts and fissures produced by the cooling at aphelion would allow the gas contained in the interior of the body to stream off under comparatively little increase of temperature. This gaseous matter, expanding into empty space and streaming off, forms the tail of the comet, which is driven away from the sun's direction by some repellant force possibly due to electrical action. That the amount of gaseous substance furnished by such a body should be sufficient to form a luminous train of the immense extent often observed in comets need not appear incredible, if we reflect that of a substance like the Kold Bokkeveld meteorite every cubic mile would furnish thirty cubic miles of gas at the pressure of the terrestrial atmosphere, and that this in space would be speedily expanded to enormous dimensions, before it would cease to be capable of transmitting electric discharges, or to be visible by reflected sunlight. As the masses of some of the comets have approached planetary dimensions there is no difficulty in accounting for the enormous trains some of them have exhibited. Moreover there is reason for believing that the meteorites which reach the earth are the spent fragments, as it were, which have already parted with a considerable portion of their gaseous constituents by the long continued action of the sun as above described, so that the amount of gas contained in some of these celestial bodies may be even much larger than that we observe in actual meteorites. We may also take into account the not inconsiderable amount of water contained in these bodies, to say nothing of the volatile carbonaceous matters which are present in some of them.

Besides the relations mentioned above, may be cited the near correspondence of the average density of the stony meteorites with the calculated density of the asteroids, which, though possibly accidental, is certainly suggestive of a community or similarity of origin.

Additional and most striking testimony to the real connection

of the meteorites and comets is afforded by the close resemblance of the spectrum of the gas obtained from the stony meteorites to the spectra of those comets which have thus far been observed.

Many observations respecting this point were made upon the gases collected from the various meteorites examined, in the course of the investigations which have been described. Vacuum-tubes of the form usually employed in spectroscopic work were attached to the pump and filled by the meteoritic gases as they were evolved. After the latter had been pumped out for the most part into the collecting tube, a freezing mixture was applied to one of the tubes of the pump and allowed to remain until the watery vapor was condensed, thus rendering the gas in the vacuum-tube very nearly free from moisture. As the vapor of mercury is always shown by spectroscopic examination to be present in tubes filled in this way by the use of a mercury-pump, small pellets of clean gold foil were previously placed in the tubes, in order to absorb the metal. This proved to be quite effectual in some cases, in others only partially so. The tubes, having now been sufficiently exhausted by the continued action of the pump, were removed, sealed, marked, and preserved for examination.

On passing the discharge of an induction coil through these tubes when placed before the slit of a spectroscope, a spectrum is seen. which varies with the conditions. That from the capillary portion of the tube shows the hydrogen lines brilliantly, together with the bands due to carbon compounds. In the wide part, however, the hydrogen lines are entirely absent, only the carbon bands being visible. When the illumination is sufficiently strong these are five in number, all sharp at the least refrangible edge, and fading gradually away at the other. When the slit is narrowed, or the tube removed to a greater distance so as to diminish the intensity of the light, only three remain visible, namely, one beginning in the yellowish-green, one in the green, and another in the greenish-blue. Of these the middle one is by far the brightest, and when the light is very much enfeebled remains visible after the others have disappeared. Of the latter, the one in the greenish-blue is brighter than the other. A resemblance to the spectra of the comets is apparent at a glance, not only in the positions, but also in the form and relative brightness of the bands. A closer comparison however shows a marked difference in their breadth, the cometary bands, as represented by various observers, covering a considerably greater space. There appeared also to be a want of exact coincidence in their positions. For the first two the difference was not greater than the discrepancies of the results given for different comets, and the bands agreed very well with some of the observations. The third band showed a greater divergence.

As the greater breadth of the cometary bands indicates a density of the cometic gases greater than that in the tubes exmained, an experiment was made, as follows, for the purpose of observing the effect of increasing the density of the gas. A glass tube, having an internal caliber of about one centimeter and some twenty centimeters in length, was closed at one end, and through the sides were inserted two platinum wires, at points near the middle of the tube, the inner ends of the wires being in its axis and separated by an interval of about one centimeter. Small fragments of the Kold Bokkeveld meteorite were dropped into the tube and shaken down into the closed end. The upper end was now drawn out to a narrow neck, and the whole attached to the pump. After exhausting the air, the neck was sealed, the tube withdrawn, and supported in a vertical position so that the interval between the wires was before the slit of the spectroscope, the end containing the meteorite being below. By means of wires connecting the platinum points with an induction coil, sparks were passed across the interval, and when the lower end of the tube was gently heated, the characteristic spectrum of the gas evolved became visible. At first it was very similar to that which had been observed previously, but as the heat was increased, and the pressure of the gas became greater, the bands were seen to widen out, until they at length fully equalled in breadth those of the comets, and finally they showed a tendency to run together. In the order of their relative intensity there was no appreciable change.

The slight disagreement in the positions of the first two bands with the reported observations of cometary spectra is readily explained when we consider that for the latter a rather wide slit is necessary in order that they may be distinctly seen. If the object viewed were a sharp fine line, the effect of opening the slit would be merely to increase its breadth without affecting the sharpness of the edges. It is easy to see however that a band, though with a narrow slit the edge were sharp and brighter than the other parts, would have its point of maximum brightness removed toward the middle of its breadth, and the farther as the opening were greater. The effect of this would be that a faint band would appear hazy at the edge, and the tendency would be to displace its apparent position towards the brightest point. Further, the measured position of the edge would be affected by the change of place of the movable edge of the slit. A simple experiment with the tube showed that the alterations from these two sources were sufficient to account for the apparent want of agreement in the positions of the bands, and also to explain some of the discrepancies in the results of different observers, as to the posi-

tion of the cometary bands, especially when regard is paid to the faintness of the light and the consequent difficulty of precise determination. Measurements of the first two bands, with the slit rather wide and the intensity of the light sufficiently diminished, were found to coincide very satisfactorily with the best recorded observations upon the corresponding bands in the spectra of comets. For the third band the result was less satisfactory, as it appears to be somewhat less refrangible than its cometary analogue, as determined by the majority of observations of the latter, though it agrees very well with some of them. Not improbably, however, the hydrocarbons existing in small quantities in some of the meteorites may be present in the comets in sufficient amount to modify their spectra somewhat.

Yale College, July 28, 1876.

ART. XXII.—*Schœnbein's Test for Nitrates;* by F. H. STORER, Professor of Agricultural Chemistry in Harvard University.

IN his important paper on the Behavior of Ozone towards Water and Nitrogen, Carius* remarks incidentally that he has not found the iodo-starch test for nitrates (employed in conjunction with zinc, as the reducing agent) a specially delicate one.

It is obvious that this test for nitrates cannot in the nature of things compare in delicacy with the similar test for nitrites, where the iodo-starch is added directly to the suspected liquid, after mere acidulation. A much smaller quantity of nitrite than of nitrate can always be detected by the above mentioned test, since the zinc, or other reducing agent, which is made to act upon the nitrate in order that the iodo-starch reaction may occur, does not in any case change the whole of the nitrate into a nitrite and no other nitrogenous product. The zinc may fail, upon the one hand, to reduce the whole of the nitrate, while upon the other its action may go too far, so that a part of the nitrite, formed at first, through reduction of the nitrate, may be reduced in its turn and removed from the field of action. Some of the nitrate is always changed, withal, to an ammonium salt and so destroyed in so far as the power of reacting upon iodo-starch is concerned.

These considerations have often been urged, and they are undoubtedly familiar to most chemists. But in the lack of a better, the iodo-starch test for nitrates has come into very general use and has been held in high estimation. The remark of Carius must have struck scores of chemists, as it did myself,

* Annalen der Chemie, 1874, clxxiv, 14, note.

as extraordinary and hardly credible. It was neither consistent with Schœnbein's statement as to the delicacy of the test nor with the reputation which the test had acquired. I have thus been led to examine the matter somewhat attentively and to subject the test anew to critical study. It appears from this examination that the lack of delicacy observed by Carius was due to the kind of manipulation employed by him, and that while his statement is doubtless literally correct it fails to convey a just idea of the much higher degree of delicacy which is readily obtainable by applying the test in a somewhat different way.

Two methods of using the test were described by Schœnbein,* viz: 1st, To add dilute sulphuric acid and iodo-starch paste directly to the nitrate solution and to stir the mixture with a zinc rod; or, 2d, and better, as we must infer from Schœnbein's statement, to reduce the neutral solution of the nitrate in the first place, by means of zinc or cadmium, thereafter to acidulate it with dilute sulphuric acid, and finally to add the iodo-starch paste. Both of these modifications have come into general use, but the second has been applied perhaps even more frequently than the first in cases where very small amounts of nitrates were to be sought for. It is in fact more delicate than the first method. Carius, however, in the experiments above referred to, employed the first modification and not the second.

For my own part, I find that the chief objection to the iodo-starch test for nitrates is by no means a lack of delicacy. The fatal defect of the test, as hitherto applied, is to be found in the fact that mere water, which is absolutely free from any contamination of nitrates or nitrites, on being treated with zinc or cadmium, as if to test it for a nitrate, will react upon iodo-starch precisely as if a trace of some nitrate had been dissolved in the water.

The explanation of this behavior is not far to seek. The coloration of the iodo-starch is caused by peroxide of hydrogen which has been formed in the water by the action of the metal, according to the familiar experiment of Schœnbein† in which peroxide of hydrogen is prepared by shaking zinc-amalgam in water and air.‡

* See for example, his paper in Fresenius's Zeitschrift analyt. Chemie, 1862, i, pp. 14, 15.

† Poggendorff's Annalen, 1861, cxii, 288.

‡ Schœnbein has himself shown (Journal für prakt. Chemie, 1861, lxxxiv, 206) that peroxide of hydrogen is formed simultaneously with a nitrite, when the aqueous solution of a nitrate is treated with zinc or cadmium, as a preliminary to the application of the iodo-starch test, but he seems to have completely overlooked the fact that the presence of the peroxide would preclude the application of his test for nitrites, in cases where the solution to be examined contained only a small quantity of the nitrate.

The amount of peroxide of hydrogen that is formed in the limited volume of liquid used, and under the conditions which ordinarily obtain when testing for a nitrate, is undoubtedly very small, but it is nevertheless sufficient to give a perfectly distinct reaction with acidulated iodo-zinc-starch solution. This reaction is far too strong to admit of its being neglected, subtracted, or allowed for, when searching for traces of nitrates. Hence it happens, that in highly dilute solutions of nitrate of potash it is impossible to detect the nitrate by means of iodo-starch as ordinarily applied, not because the products of the reduction of the nitrate by zinc, or the like, cease to act upon the iodo-starch, but because the reaction produced by these products is identical with that of the peroxide of hydrogen that is formed simultaneously with them, and which would be formed just as well in pure water totally devoid of nitrates.

Whenever the degree of coloration of the iodo-starch obtained, in testing for a nitrate according to Schœnbein's method, is less intense than the tint obtainable from 0·0001 gram N_2O_5 (=0·000187 gram KNO_3) in 50 c.c. water it is difficult to decide whether the coloration may not be wholly due to peroxide of hydrogen. It is easy, at all events, to obtain as much peroxide of hydrogen by boiling cadmium, zinc or amalgamated zinc with mere water, as will give a reaction with acidulated iodo-zinc-starch equal to that obtainable from 0·00005 gram N_2O_5 or perhaps even more. The following experiments will illustrate this point.

A. To 50 c.c. of pure water 0·00005 gram N_2O_5 (in the form of 0·0000936 gram of nitrate of potash) was added, the mixture was boiled five minutes with a piece of cadmium, in a small flask, then cooled, transferred to a porcelain capsule, acidulated and tested with iodo-zinc-starch.

B. The same experiment was repeated with pure water to which no nitrate had been added.

C. Same as A., with the exception that zinc was used instead of cadmium.

D. Same as B., with the exception that zinc was used instead of cadmium.

The four capsules were placed side by side under a darkened bell glass and left to stand over night. On examination it appeared that while the contents of capsules B, C and D seemed to be of one and the same depth of color, the contents of capsule A were distinctly lighter colored than those of either of the other dishes. These experiments were simultaneous, and care was taken that they should be strictly comparable one with another. Each experiment was conducted as if a nitrate were being tested for. Equal surfaces of metal, as nearly as might be, were exposed to the action of the liquids, in each instance.

Repetitions of these tests gave similar or analogous results Sometimes the contents of one capsule in the series would be more or less strongly colored than the rest and at other times another, but everything went to show that by this method of testing. traces of nitrates cannot be distinguished from the peroxide of hydrogen that is naturally formed in the liquid under examination. So too, when amalgamated zinc was used instead of the simple zinc or cadmium. It is true, as Schœnbein* has said, that water which contains only $\frac{1}{10000}$ of nitrate of potash will color iodo-starch blue, after having been shaken or boiled with bits of amalgamated zinc, filtered, and acidulated with sulphuric acid; but since water that is absolutely free from nitrates will do almost precisely the same thing when similarly treated, the statement is of no value either as regards the delicacy of the test, or the limit of its applicability.

Proof that the cause of the reaction in the water free from nitrates is really due to the presence of peroxide of hydrogen is readily obtained on testing the neutral liquid for that substance, with a drop or two of a weak solution of ferrous sulphate† and the solution of iodo-zinc-starch. The characteristic blue coloration of the iodo-starch will quickly appear when pure water that has been boiled with cadmium or with zinc is subjected to this test, while no reaction is obtained, even after the lapse of many hours, when pure water that has not been in contact with a metal is similarly treated.

With pure water these results are constant and invariable, but it is noteworthy that on testing in this way, samples of water taken from wells, and of rain water taken respectively from a brick and from a leaden cistern, no reaction for peroxide of hydrogen was obtained after simple boiling for five minutes with the cadmium, though on boiling with cadmium and then leaving the liquid to stand upon the metal for twenty-four hours a reaction for the peroxide was finally obtained with the rain water. So too when the pure water was tested in a somewhat different way by mixing it directly with the solutions of iodo-zinc-starch and sulphate of iron and ammonia, and placing a piece of cadmium in the mixture, the blue coloration soon appeared, while no such coloration was observed when samples of rain or well water were tested in this way; far from becoming blue, the liquids soon acquired a rusty color, as if from oxidation of the iron salt.

Care was taken to control the peroxide reactions by apply-

* Zeitschrift analyt. Chemie, 1862, i, 15.

† Or instead of simple ferrous sulphate, the double sulphate of protoxide of iron and ammonia may be used with advantage, as was suggested by Struve, Fresenius's Zeitschrift analyt. Chemie, 1869, viii, 319. Most of the tests described in the text were made with this double salt. Two or three drops of a $\frac{1}{100}$ normal solution of it were ordinarily used.

ing the test (ammonium-ferrous sulphate and iodo-zinc-starch) to acidulated water, that had not been in contact with cadmium or zinc, to acidulated and to neutral solutions of pure nitrate of potash, to neutral solutions of nitrite of soda, all made with pure water, and to the distillate from a solution of nitrite of soda that had been boiled with dilute sulphuric acid. But no trace of blue coloration was observed in either instance.

Corroborative evidence of the presence of peroxide of hydrogen in the water that had been boiled with cadmium was obtained as follows: Two portions, each of 100 c.c., of pure water, were taken. To one portion two hundredths of a milligram of nitrous acid was added, in the form of nitrite of soda, together with 2 c.c. of dilute sulphuric acid (1:4) and the mixture was boiled for ten minutes in order to expel the nitrous acid. The other portion was boiled with cadmium, as if it were to be tested for a nitrate, the cadmium was removed, the liquid was mixed with 2 c.c. of the dilute acid and then boiled for ten minutes. Each portion was finally tested, when cold, with iodo-zinc-starch. The second portion, viz: the one to which no nitrite had been added, speedily gave a reaction, but the first portion did not. After standing twelve hours in the dark, the first portion remained colorless, while the second portion was distinctly blue. In a word, the nitrous acid known to have been present in the first portion had been completely expelled by the boiling, while much of the peroxide of hydrogen in the second portion had remained intact.

The fact that highly dilute aqueous solutions of peroxide of hydrogen suffer but little decomposition at the temperature of boiling has often been insisted upon;* but less attention seems to have been paid to the equally important fact † that some of the peroxide goes forward, as such, with the vapor of water, and may be detected in the distillate. This volatility of the peroxide is a point of no little significance for the analyst, since it makes it very much more difficult than would otherwise be the case to detect traces of nitrites in solutions suspected to contain them, as well as the peroxide. Contrary to the opinion expressed by Plugge ‡ it would be altogether useless in delicate experiments to apply, in the presence of peroxide of hydrogen, that method of testing for nitrites which depends upon the volatility of nitrous acid, viz: the distillation of the nitrite solution with a dilute acid and subsequent testing, with iodo-starch plus acid, for nitrous acid in the distillate. The following experiments will illustrate the importance of this consideration. Two portions of pure water, each of 250 c.c., were taken, and one was distilled directly with

* Compare Gmelin-Kraut's Handbuch der Chemie, 1872, i (2te Abth.), p. 58.

† First recognized, I believe, by Schœnbein. See Will's Jahresbericht, 1866, p. 105.

‡ Fresenius's Zeitschrift analyt. Chemie, 1875, xiv, 141.

acetic acid while the other was boiled with cadmium for five minutes and thereafter distilled with acetic acid, pains being taken to make the two experiments alike in all other respects. The first 50 c.c. of distillate were collected in each instance and tested with iodo-zinc starch, after acidulation. No reaction was obtained in the distillate from the mere water and acetic acid, while the distillate from the water that had been boiled upon cadmium became colored in less than half an hour. Repetitions of this experiment gave similar results.

That only a part of the peroxide goes forward with the steam will be seen from the following trials:—Two separate 250 c.c. portions of pure water that had just been distilled off from a flask containing a mixture of zinc and spongy copper were boiled with cadmium, and a part of each of the liquids was tested directly with iodo-zinc starch plus acid, while the remainders were distilled with acetic acid and the first 50 c.c. of distillate was subjected to the test in each instance. In both trials the portions tested directly gave a stronger coloration than was obtained in either of the distillates. In order to be sure that the acetic acid had no improper influence on these reactions, several portions of pure water were distilled with the acetic acid for a time, a fresh portion of the acetic acid was then added and the next 50 c.c. of distillate was tested with iodo-zinc starch plus acid, but no reactions were obtained, although the mixtures were allowed to stand twenty-four hours after the application of the test.

It may be mentioned in this connection that the tendency of peroxide of hydrogen to be transported with the vapor of water may perhaps afford the true explanation of the cause of the presence of the peroxide in some of the solutions examined by Meissner in his Untersuchungen über Sauerstoff, Hannover, 1863, pp. 94–110. Such transportation of the peroxide may account moreover for the presence of this substance in the outer or water tube of Schœnbein's and Meissner's (op. cit., p. 74) earlier experiments on the making of peroxide of hydrogen from peroxide of barium and sulphuric acid, without need of supposing that the "antozone" of these chemists had any part in the reaction.

With regard to the delicacy of the iodo-starch test for nitrates, supposing there were no interference from peroxide of hydrogen, it appears, as has been stated above, that that method of procedure in which the nitrate is reduced by itself, as a separate, preliminary step, before the acidulation of the liquor or the addition of the iodo-starch, is decidedly preferable to the other system of adding the iodo-starch, the acid, and the reducing agent all at once to the nitrate solution. As Goppelsrœder*

* Poggendorff's Annalen, 1862, cxv, 128.

has remarked, it seems to be immaterial whether the nitrate solution be boiled for a few moments with the cadmium or zinc, or left to stand for some hours in the cold in contact with one of these metals; though the boiling will usually be found more convenient in practice.

It has been customary hitherto, in this laboratory, to proceed as follows, when testing for nitrates by Schœnbein's process: 100 c. c. of the suspected liquid were put in a small glass flask, together with bits of metallic cadmium and boiled for five minutes. When the liquid had become cold half of it was transferred to a small porcelain dish, one c. c. of dilute sulphuric acid* was added to it, and finally, two c. c. of iodo-zinc-starch solution.† The capsule, with its contents, was then placed under a darkened bell-glass and examined at stated intervals. Tested in this way, a solution of nitrate of potash, containing

* The dilute sulphuric acid is prepared by mixing one volume of oil of vitriol with three volumes of pure water, boiling the mixture for an hour, and finally adding enough pure water to replace that which has evaporated.

† The solution of iodo-zinc-starch is prepared as follows, after Kubel-Tiemann, "Anleitung zur Untersuchung von Wasser," Braunschweig, 1874, p. 140: Rub 4 grams of starch in a porcelain mortar with a little water, and pour the smooth, milky liquid, little by little, into a boiling solution of 20 grams pure commercial chloride of zinc in 100 c. c. of distilled water. Continue to boil the mixture until as much of the starch as possible has dissolved, and the liquid has become almost clear, taking care meanwhile to replace the water that evaporates. Dilute with distilled water; add 2 grams of pure, dry, commercial iodide of zinc; bring the volume of the liquid to a litre, and pour it into a tall cylinder, to settle. After several days, decant the clear liquid and keep it in the dark in well-closed bottles.

Pure water is obtained as follows: Enough crystallized permanganate of potash is dissolved in rain-water to color the liquid strongly; the mixture is left to stand for 24 hours, and then transferred to a copper still. A lump of lime is added and the mixture is distilled slowly, the first fractions of distillate being rejected. The rest of the distillate is redistilled in a glass flask, upon lime, and the new distillate is rejected until it ceases to show ammonia when tested with Nessler's reagent. Such water is free from ammonia and from nitrates, and when tested for nitrites with iodo-zinc-starch, plus acid, it will not show any trace of coloration at the end of an hour, and will seldom show any appreciable tinge of color when the mixture is left to stand over night, though on standing for 24 hours a faint shade of color will usually appear. I have commonly attributed this tendency to give a reaction to the presence of an infinitesimal trace of nitrite, but it is not impossible that it may be due to peroxide of hydrogen that has been formed by means of the copper of the still. It would undoubtedly be better, when possible, to perform all the distillations in glass vessels. However that may be, such water is abundantly pure enough for the purposes of this research. For cases where absolute purity is essential, water that will not give any reaction for nitrites may be prepared, by acidulating with acid sulphate of soda the pure water obtained as above (from glass vessels) and redistilling it in a glass flask. Free nitrous acid being readily volatile will go forward in the first portions of distillate from the acidulated water, so that, by rejecting a considerable fraction of the distillate at first and saving the water that comes over later, it is no very difficult matter to obtain water that is perfectly free from all three of the nitrogen compounds now in question as well as from peroxide of hydrogen.

Most well waters it should be said, are, if anything, rather better than rain-water for preparing a pure product.

By making the mixture of permanganate and water alkaline with lime instead of a caustic alkali, the nitrous compounds which almost always contaminate the latter are avoided.

0·0005 grm. N_2O_5 in 50 c. c. water, gave an immediate coloration on being mixed with iodo-zinc-starch plus acid, after having been boiled for five minutes upon cadmium; with a solution containing 0·0002 grm. N_2O_5 the blue coloration appeared about 5 minutes after the addition of the iodo-starch, and with a solution containing 0·0001 grm. N_2O_5 the color began to appear in about 8 minutes. The last named quantity indicates very nearly the limit of applicability of the test, since the degree of coloration derivable from an amount of the nitrate any smaller than this, could hardly be distinguished from that due to the peroxide of hydrogen that is obtained on boiling pure water upon cadmium or zinc. It is true that the coloration caused by the products of the reduction of a nitrate generally appears rather more speedily than the coloration produced by peroxide of hydrogen, but since the reaction of the peroxide often begins to show ten or fifteen minutes after the addition of the iodo-zinc-starch and acid, and sometimes even sooner, no dependence can be placed upon mere rapidity in the appearance of the coloration, as a means of distinguishing the nitrate from the peroxide. In case the mixtures are left to stand over night, or for a number of hours, after the iodo-starch has been added, this seeming advantage in favor of the nitrate solutions disappears, for after long standing the coloration due to peroxide of hydrogen is often as deep as that obtained from 0·00005 grm. N_2O_5, and the difference between this tint and that obtained from 0·0001 is by no means large enough to permit of distinguishing the one from the other with any certainty.

Results very different from the foregoing were obtained when 50 c.c. of the pure nitrate solution, mixed directly with two drops of the dilute acid and 2 c.c. of the iodo-zinc-starch solution, were left to stand in contact with a rod of zinc, according to the method employed by Carius.* On proceeding in this way, a solution containing 0·01 grm. of N_2O_5 (=0·01872 grm. KNO_3), in 50 c.c. of water gave a reaction almost immediately when the zinc was added; and a solution containing 0·005 grm. N_2O_5 (=0·00936 grm. KNO_3) began to show a blue coloration at the lower end of the zinc rod in a few minutes, while in a solution containing 0·002 grm. N_2O_5 (=0·00374 grm. KNO_3) no coloration could be perceived even after the lapse of two hours, though the liquid was examined at frequent intervals. On repeating this trial with 0·002 grm. N_2O_5 a similar result was obtained. 0·003 grm. N_2O_5 (=0·005616 grm. KNO_3) in 50 c.c. water gave a very slight coloration at the lower end of the zinc rod after a comparatively short time. Trials similar to the above, in which amalgamated zinc was used instead of simple zinc, gave

* Annalen der Chemie, 1874, clxxiv, 14.

no better results, but rather worse on the whole. Rods of cadmium appeared to be somewhat preferable to those of zinc, though not much.

It will be observed that the results of these tests are even less favorable than those obtained by Carius, since this chemist puts the limit of delicacy at 0·0015 grm. KNO_3 in 50 c.c. water. The following experiments moreover go to show that when the test is used in this manner the presence of trifling impurities in the solution to be examined may interfere with the reaction very decidedly and render the negative indications of the test untrustworthy even at the comparatively low degree of delicacy above mentioned. Thus, on repeating some of the foregoing trials and using rain-water to dissolve the nitrate, instead of the pure water previously used (see page 182, note) less favorable results were obtained. A solution of the nitrate equal to 0·005 grm N_2O_5, in 50 c.c. cistern water gave no reaction with the iodo-zinc-starch in the course of an hour. On repeating the trial with cistern-water that had just been boiled, a slight reaction was obtained, but the blue color instead of increasing faded away after a time and disappeared. The proportion of acid employed to acidulate the mixture is not without influence upon the delicacy of the test, and it may well be that in order to the best results a larger amount of acid is required than was used in the foregoing trials. The small quantity of the acid actually taken was chosen in order to conform to Carius's injunction that "the addition of but little acid is a condition of success." But it appeared once on repeating the trial with the nitrate solution, in pure water, that contained 0·005 grm. N_2O_5 in 50 c.c., that while no coloration of the iodo-starch had appeared after some time so long as only two drops of sulphuric acid had been added, the reaction soon set in on the addition of two more drops of the acid.

The defect of the usual method of testing for nitrates having been made apparent, I have naturally endeavored to discover some better method of procedure which, while preserving all the delicacy of the test, should permit its general application. Casting about for some means of reducing nitrates to nitrites which should not at the same time occasion the formation of peroxide of hydrogen, I have finally hit upon the simple device of boiling the nitrate with metallic cadmium in water that is slightly acidulated, instead of operating with neutral solutions, as has hitherto been recommended. Contrary to what might have been inferred from what has been published hitherto, and from what is known of the action of acidulated water upon metals in the cold, no peroxide of hydrogen is formed when water slightly acidulated with sulphuric acid is boiled upon metallic cadmium; and since the reduction of

nitrates to nitrites by means of cadmium occurs readily in such boiling acidulated solutions it happens that the iodo-starch test can be employed in this way for the detection of nitrates without difficulty and with a high degree of certainty. The only special precautions to be taken are to test the boiled liquid with litmus paper in order to be sure of its acidity, and to guard against the loss of any nitrous acid by volatilization. This can readily be done by attaching to the small flask in which the nitrate is reduced a small inverted Liebig's condenser, through the sleeve of which a stream of cold water is made to flow. The following experiments will illustrate the delicacy of this new method of testing:

A. 0·0005 grm. N_2O_5, in the form of nitrate of potash, was boiled for five minutes upon metallic cadmium in 50 c.c. of pure water to which two drops of the dilute sulphuric acid, of p. 182, had been added. On testing with iodo-zinc-starch plus acid a strong reaction was obtained, almost immediately.

B. 0·0002 grm. N_2O_5 similarly treated gave a reaction in about five minutes.

C. 0·0001 grm. N_2O_5 gave a reaction in rather less than fifteen minutes.

D. 50 c.c. of pure water acidulated with two drops of the dilute sulphuric acid, and boiled upon cadmium, without any addition of a nitrate, gave no reaction with iodo-zinc-starch plus acid, not even on standing over night.

Repetitions of these trials gave results that were identical with the foregoing.

E. 0·00005 grm. N_2O_5 in 50 c.c. of pure water was tested, as above, in comparison with pure water devoid of nitrate. At the end of half an hour the solution that had contained the nitrate gave a rather strong coloration with the iodo-starch, while the pure water remained perfectly colorless.

F. 0·00001 grm. N_2O_5 in 50 c.c. water was tested as above. But no reaction was obtained with the iodo-starch, not even after the lapse of 36 hours.

G. In order to determine whether metallic cadmium in acidulated water actually destroys peroxide of hydrogen at the temperature of boiling, 100 c.c. of pure water were boiled upon cadmium and left to stand in contact with the metal over night; the water thus charged with peroxide was divided into two equal portions, one of which was tested directly with iodo-starch plus acid, while the other was acidulated with two drops of dilute sulphuric acid, again boiled upon cadmium and then tested. A strong reaction was obtained in the portion tested directly, but no reaction was obtained from the acidulated portion until after the lapse of two hours, and then the coloration was but slight. In repeating this experiment, 100 c. c. of pure

water were boiled upon cadmium for five minutes; 50 c. c. of the water were then poured off to be tested, while two drops of dilute sulphuric acid were added to the flask, and the acidulated liquid was again boiled for five minutes with the cadmium. On decanting and testing the acidulated liquid with iodo-starch, it gave no coloration, not even after the mixture had stood over night, while on testing the portion that had been boiled without acid it gave a strong coloration in due course.

H. To see if hydrogen alone would so quickly destroy the peroxide, a stream of hydrogen gas was made to flow during five minutes through a solution of peroxide of hydrogen, prepared as above, that was kept at the temperature of boiling. But the liquid thus treated gave almost as strong a reaction with iodo-starch after the passage of the hydrogen as it had done before.

On trying whether some one of the more common metals might not perhaps be used in testing for nitrates by the new method, it appeared that neither of them is on the whole so well fitted for the purpose as cadmium. Thus on repeating the foregoing experiments, with zinc, amalgamated zinc, aluminum, and iron, it appeared that while no peroxide of hydrogen was formed on boiling acidulated water upon these metals, neither of them was so well fitted as cadmium to reduce nitrates to nitrites in acidulated solutions. From zinc and from amalgamated zinc, distinct reactions were obtained with solutions containing 0·0005 grm. N_2O_5 in 50 c.c. water, when the iodo-starch mixture was left to stand over night, though no coloration appeared until after the lapse of more than two hours; slight reactions were obtained also, after long standing, from solutions that contained 0·0001 grm. N_2O_5; but no reaction was obtained in a solution that contained 0·00005 grm. N_2O_5. From aluminum a slight coloration of the iodo-starch was obtained, after two hours standing, with a solution that contained 0·01 grm. N_2O_5 in 100 c.c. water, and a stronger reaction was got from a solution that contained more of the nitrate. From iron no reaction was obtained, in the course of two hours, with a solution containing 0·01 grm. N_2O_5 in 100 c.c. water, though with a considerably stronger solution a reaction was obtained. A solution containing 0·01 grm. N_2O_5 in 100 c.c. water boiled upon a mixture of iron and platinum gave a reaction almost immediately, but one containing 0·001 grm. N_2O_5 gave no reaction after having been boiled upon the mixed iron and platinum. No reaction was obtained with a solution containing 0·01 grm. N_2O_5 in 100 c.c. water after adding to it a small quantity of acidulated sulphate of silver and boiling the mixture upon iron.

Both lead and magnesium easily reduce nitrates to nitrites in

acidulated solutions, magnesium perhaps even more readily than cadmium, but neither of them would seem to be so good as cadmium for use in testing for nitrates since they form peroxide of hydrogen when boiled in water that is no more strongly acidulated than that just described. The trouble with both metals, but particularly with magnesium, seems to be that they combine with and consume the acid too rapidly so that the solution becomes neutral or well nigh neutral, and fit for the production of peroxide of hydrogen, before the boiling process is finished.

In experiments with lead it was found that a solution containing 0·0001 grm. N_2O_5 in 50 c.c. gave a decided reaction with iodo-starch in less than half an hour, and that a solution containing 0·00005 grm. N_2O_5 gave a distinct reaction in half an hour, though it was not quite as strong as the reaction obtained with cadmium under similar circumstances. 50 c.c. pure water plus two drops dilute sulphuric acid, boiled five minutes upon lead without the addition of any nitrate gave a slight reaction with iodo-starch and acid on standing over night; but on repeating the experiment with four drops of acid no reaction was obtained.

In experiments with magnesium it was found that nitrate solutions containing respectively 0·0001 and 0·00005 grm. N_2O_5 in 50 c.c. water gave reactions with acidulated iodo-starch within fifteen minutes; and that a solution containing 0·00001 grm. N_2O_5 plus four drops of acid gave a distinct reaction on standing over night. But 50 c.c. pure water plus two drops dilute sulphuric acid boiled five minutes upon magnesium without addition of any nitrate gave a slight reaction in the course of two hours, and on repeating the experiment, with four drops of acid a slight reaction was obtained on leaving the mixture to stand over night, though none was visible at the end of two hours. With silver, an acidulated solution containing 0·025 grm. N_2O_5 in 50 c.c. water gave a very slight reaction with iodo-starch in the course of two hours, while a weaker neutral solution, containing 0·01 grm. N_2O_5 in 100 c.c. water, that was boiled upon silver gave no reaction.

It is to be observed that in the foregoing set of experiments the solutions were acidulated in every instance before the boiling, and that an inverted condenser was always attached to the flask in order to prevent the escape of any nitrous acid.

Solutions containing 0·005 grm. N_2O_5 in 50 c.c. acidulated water, left in contact for eight hours or more in the cold with metallic aluminum, iron or zinc, and then tested with iodo-starch gave no reaction in the cases of iron and zinc, and only a slight coloration in the case of aluminum.

No reaction for peroxide of hydrogen was obtained in acid-

ulated water that had been boiled five minutes upon a mixture of pieces of tin and platinum, nor was any reaction obtained from an acidulated solution of nitrate of potash that had been similarly boiled.

Numerous trials were made to discover, if possible, some reducing agent which, though proper to change nitrates to nitrites in neutral solutions, should not form peroxide of hydrogen in such solutions; but all these efforts were unsuccessful. In point of fact there are comparatively few chemicals capable of reducing nitrates to nitrites in presence of much water; while most, if not all, of these substances readily form peroxide of hydrogen when left in contact with water and air. Among metals,* I have found only iron and lead that seem to be at all fit to be used as substitutes for cadmium or zinc, in testing for nitrates by the old method. Both these metals readily reduce nitrates to nitrites in dilute neutral solutions at the boiling temperature; but they, as well as magnesium, aluminum, and copper,† cause the formation of peroxide of hydrogen also, when boiled in pure water. Aluminum, though it reduces nitrates to nitrites in neutral solutions, seems to be inferior to zinc for this purpose, and magnesium, though it reduces nitrates very readily in neutral solutions, seems to form peroxide of hydrogen even more easily than cadmium.

The behavior of iron and lead towards nitrates will appear from the following statement: Neutral solutions of nitrate of potash, containing in 100 c. c. of water 0·01 grm. (or more) of N_2O_5, gave a strong reaction with the iodo-starch, after having been boiled five minutes upon iron wire; with 0·001 grm. N_2O_5 the reaction soon appeared, and with 0·0001 grm. N_2O_5 the reaction appeared after some little time. A special experiment was made, as follows, to test the efficiency of iron as compared with that of cadmium or zinc: 50 c. c. of pure water were boiled for five minutes upon iron wire in one flask, while in another flask 50 c. c. of pure water, plus 0·0005 grm. N_2O_5, in the form of nitrate of potash, were boiled upon an equal amount

* I have, as yet, made no experiments with the alkali metals or their amalgams.

† And various other metals, as recorded in Gmelin Kraut's Handbuch, i (2 Abth.), p. 56.

Since the above statement, that iron forms peroxide of hydrogen on being boiled with water in contact with air, may seem to conflict with Schœnbein's observation that the peroxide is not formed when iron is shaken in water and air, it may be well to give the evidence on which it depends. Pure water was boiled with iron wire for five minutes; the cold liquid was mixed with iodo-zinc-starch solution and dilute sulphuric acid, and left to stand over night. A purplish coloration was obtained. On repeating the experiment, a precisely similar reaction was observed. This coloration is rather less, it should be said, than that obtained from the other metals enumerated above; but is, nevertheless, perfectly distinct and characteristic. In still another experiment, where pure water was boiled upon sheet iron, no reaction for peroxide of hydrogen was obtained. The liquid assumed a rusty tint, and no blue coloration could be perceived.

of the iron wire. When cold, the liquids were transferred to porcelain capsules, mixed with iodo-zinc-starch and acid, and left to stand over night. Decided reactions were obtained in both instances, but the liquid to which the nitrate had been added was deeper colored than the other, and the difference in tint between the contents of the two dishes seemed to be rather more marked than was the case in similar experiments where cadmium or zinc had been used instead of iron. It is not unlikely that iron would have been rather better fitted than either of these metals, for use in testing for nitrates according to the old plan.

On repeating this last experiment with metallic lead, instead of iron, decided reactions were obtained with the iodo-starch in both dishes; but the colorations were of about the same depth as those ordinarily obtained with cadmium, and that obtained from the nitrate solution was no stronger than that from the pure water.

Solutions of nitrate of potash (0·01 grm. N_2O_5 to 100 c. c. water), made alkaline with potash or with lime, were reduced, with formation of some nitrite, when boiled for five minutes upon iron, or left to stand over night in contact with the metal in the cold; but the reactions with iodo-starch that were obtained in this way were less strong than those got by operating upon neutral solutions of the nitrate.

The following substances failed to reduce nitrate of potash when boiled for five minutes with neutral solutions of that substance, containing 0·025 grm. N_2O_5 in 100 c. c. water, or, at the least, no reaction could be obtained with the iodo-starch after using them, viz: filter-paper, phosphorus (ordinary and amorphous), arsenic, ferrous sulphate, ferrous sulphide, and sulphite of lead. No reaction was obtained when acidulated solutions of the nitrate, of the above mentioned strength, were boiled with stannous chloride, ferrous sulphate, glucose, or arsenic. No reduction to nitrite was detected when solutions of the nitrate that had been mixed with lime were digested with ordinary or amorphous phosphorus, glucose, or ferrous sulphide, or when a solution that had been mixed with hydrate of potash was boiled upon metallic arsenic.

On the other hand, recently precipitated cupreous oxide, boiled for five minutes with neutral, acid, and alkaline solutions of nitrate of potash (0·01 N_2O_5 in 100 c. c. water), reduced some of the nitrate in each instance, so that reactions were obtained on adding iodo-starch to the several filtrates, but as the reactions were not very strong there seemed to be little encouragement to proceed with the inquiry.

If it were less difficult than it is, to manipulate with thoroughly boiled water so that no atmospheric air should come

into contact with it, it would be possible, by using such water, to avoid the interference of peroxide of hydrogen, in testing for nitrates in neutral solutions by Schœnbein's process; for, out of contact with the air, no peroxide of hydrogen is formed by the action of cadmium or zinc upon water that has been thoroughly boiled, in a glass flask, provided with a long and very narrow outlet. Even when no special pains are taken to preserve such water from contact with the atmosphere after the boiling, it is easy to perceive that peroxide of hydrogen does not readily form in it. So too, though in a lesser degree, with water that has been well nigh completely deprived of air by distillation in the vacuum of an air-pump. But no such inability to yield peroxide of hydrogen was observed in water that had been boiled for a long time in a copper flask, into the neck of which a long and very narrow brass tube had been soldered. The boiled water from the copper flask gave a reaction for the peroxide even when tested directly, without having been put in contact with any other metal.

I am much indebted to my assistant, Mr. D. S. Lewis, for his coöperation in this investigation.

Bussey Institution, Jamaica Plain, Mass., June, 1876.

ART. XXIII.—*Note on the double decomposition of Potassic Bromide and Sodic Chloride;* by J. H. BILL, Surgeon U. S. Army.

IN the practice of analytical chemistry it is the custom in arranging and recording the results to associate the "strongest acid" with the "strongest base." Thus, if barium, potassium, sulphuric and nitric anhydrides are found in a compound, in the statement of the analysis we associate together the barium and sulphuric anhydride and the potassium and nitric anhydride.

In this record nothing is assumed, for the basic sulphate separates as an insoluble powder, the potassic nitrate remaining in solution a soluble crystalloid.

Again, if potassium, sodium, chlorine and bromine, are found in a mixture we record the results as so much potassic chloride and sodic bromide, or if we mix solutions of potassic bromide and sodic chloride we hold that potassic chloride and sodic bromide exist in the mixture in consequence of a double decomposition. On what do we rest such an assumption? Is it on anything more than analogy? The haloid salts of potassium and of sodium have nearly the same solubility, and crystalline forms. We get no precipitate on mixing their solutions, nor characteristic crystals on evaporating these, nor change of

color in the solutions themselves, nor other evidence that the chemical relations of the several bodies have been altered. In short our belief in this alteration is purely hypothetical.

Several years ago while conducting a physiological research on the action of the bromides I observed certain facts which I here offer as a demonstration of the proposition that potassic bromide and sodic chloride, when brought together in solution, undergo double decomposition.

If five or six grams of potassic bromide are administered to a healthy man, his urine of the succeeding twenty-four hours will show the following changes: Nearly all the potassium ingested as potassic bromide will be found in the urine in addition to that naturally present, united with chlorine augmented according to the amount of bromide taken; the sodium scarcely altered in quantity; the sulphates and phosphates unchanged: only a very little bromine will be found. Bromides, however, may be detected for two weeks after the last dose taken, whilst excess of potassium will be found only after the first day.

I can account for these facts only on the supposition that the potassic bromide ingested was decomposed by the sodic chloride of the blood, potassic chloride—excreted by the urine—and sodic bromide—retained in the blood as a substitute for sodic chloride—resulting.

Further, this decomposition was the result of simple chemical affinity. We know of no instance where a "vital force" changes in the body the usual action of chemical force and we have no right to assume it here. We hold the reaction therefore to be a universal one. I submit the average result of three analyses when no bromide was taken, and the average results of six analyses of urine when the body was under the influence of from five to ten grams of potassic bromide. The results show the amounts of the whole twenty-four hours, all the urine for that period being collected. The method was to incinerate a portion of the urine and from the ash to separate the alkaline earths, sulphates and phosphates. The sodium and potassium were then estimated in the form of chlorides by the indirect method. The chlorine and bromine were also estimated indirectly.

	Potassium. grms.	Sodium. grms.	Chlorine. grms.	Bromide. grms.
No bromide taken	4·21	7·67	9·56	----
Seven grains (average) of bromide taken	6·52	7·82	11·45	0·04

I have waited for a chance to extend these experiments to the reaction of the iodides and chlorides, but seeing no probability that an immediate opportunity of doing so will present itself I publish this note for what it is worth.

New York, June 15, 1876.

Art. XXIV.—*Note on Erosion;* by James D. Dana.

In Professor Gilbert's very valuable paper on "The Colorado Plateau Province,"* the author speaks of the process of erosion† as including the three general divisions, "(1) *weathering*, (2) *transportation*, and (3) *corrasion*;" and states that "corrasion is performed by solution, and by mechanical wear;" that the mechanical wear is due to the blows which the moving fragments [of the detritus] deal upon the stream bed, and among themselves; and that "the element of velocity is of double importance, since it determines, not only the speed, but, to a great extent, the size of the pestles which grind the rocks." He further observes, in his excellent explanatory analysis of the mechanical action of flowing water, that the energy of a stream is used up in transportation, corrasion, and friction, either one or all; and that sometimes partly also, but not usually so, in producing an increase in the velocity of flow; that the energy "in a clear stream is entirely consumed in friction on its bottom," and in one that is loaded to its full capacity with detritus, in transportation. From these principles, he concludes that "if a stream has no load of detritus it corrades only by solution," that is, by softening and dissolving away the rocks.

The eroding action directly connected with friction is not dwelt upon by Professor Gilbert, nor distinctly included in the "general divisions" of erosion which he enumerates, although he is unquestionably familiar with the facts; and a few words on the subject are therefore here added, since an appreciation of the work which may thus be done appears to be essential to a full understanding of the method of cañon-making.

The impinging of the flowing waters against the bottom and sides of a stream generally causes, besides a diminution of velocity owing to friction, an overcoming of adhesion, and of other sources of resistance to displacement, in the material acted upon. The operation is exhibited, on a small scale, at the placers of California and the Rocky Mountains, where a stream of water—strictly a water-fall—strikes, in a jet, the rather firmly consolidated gravel bank, and, in an incredibly short time, levels the thick deposits over a large area. The water that impinges has "no load of detritus," and yet it erodes with tremendous efficiency. The flooded rivers that tear houses from their foundations, and break off or uproot trees, afford other examples; for the work is, first, rending, and then, transportation. The sudden rise of several feet or yards in a mountain stream, or along a western cañon, sometimes occurring as

* This volume, pages 16, 85. † Ibid., p. 89.

a consequence of a severe and short storm, often affords, as is well known, vast effects of this kind.

Flowing water, causes easily, through this method of erosion, a rapid destruction of those deposits that are imperfectly cemented; but not these alone. It may cause a rapid degradation also of hard rocks. For granite, quartzyte, sandstone, limestone, and other rocks equally firm, are generally jointed throughout, that is, intersected everywhere by a system of fractures; and many kinds also break easily into slates, flags, or chips, even without a previous weakening by weathering. Consequently, when the waters, swollen to flood height and quickened immensely in velocity, plunge along a gorge, they readily tear, shove, or wrench out of place blocks or slabs exposed in the walls to their violence. As the waters hurry on, they dash in many places, with the full force of the stream, against projecting ledges, and drive into all crevices or openings, causing a vast amount of degradation; and much additional by undermining and toppling down the piles of strata above.

Such waters in the rocky regions of the west, where the bed and gorge are rock-made, transport, in their greatest floods but a small part of the detritus which at so rapid a rate of flow they could carry, and hence, comparatively little of the energy is used up in transportation. Moreover, the descent in the cañoned streams of the Rocky Mountain slopes is often—much oftener, probably, than Professor Gilbert seems to allow—sufficient to produce an increasing velocity as a direct consequence of the fall, and hence an accumulation, thereby, of working force or energy; and all this would augment greatly the results. The clearer the waters, the greater will be the velocity, and, hence, the vaster the amount of degradation by this means—though detritus would increase the effects if the velocity remained the same.

It has been well said that glaciers depend largely for their work in the way of erosion on the jointed condition of the rocks over which they pass, these making it easy for the moving ice to force out of place great masses for transportation, and so make rapid progress in degradation; and that the abrasion by means of stones in the bottom of the ice is comparatively of trifling importance. I am strongly inclined to believe that the same general fact is true as regards erosion by rapid rivers over a rocky region; and hence that the results of *friction*, or of the *blows of the impinging torrent.* are the chief means of degradation in most cases of cañon-making; that *abrasion*, or the wear of the sides and bottom by transported stones and earth (included under corrasion by Professor Gilbert), is of next importance; while the mutual wear of the transported particles or fragments, or *corrasion*, aids in clearing the gorge of the dislodged material.

ART. XXV.—*Classified List of Rocks observed in the Huronian Series, south of Lake Superior, with remarks on their abundance, transitions, and geographical distribution; also a tabular presentation of the Sequence of the beds, with an Hypothesis of Equivalency;* by T. B. BROOKS.

DURING the last ten years I have explored more or less thoroughly the east and north portions—about one-third—of the large Archæan area lying southwest of Lake Superior, embracing the iron and copper regions of northern Michigan and Wisconsin.* Besides observations in the field, I have collected and catalogued over 3,000 rock specimens, mostly Huronian, embracing, it is believed, all the kinds and most of the varieties to be observed in that portion of the region which came under my observation. The most interesting of these specimens having now been more or less thoroughly studied by competent lithologists, I feel warranted in preparing the following list of names with classification. They are based largely on a microscopic study of over 200 thin sections of typical rocks, made by Dr. A. Wichmann† of Leipsic under the supervision of Prof. Zirkel, an equal amount of similar work by Mr. Chas. E. Wright,‡ together with a considerable number of similar examinations made by Mr. Frank Rutley of London. Dr. T. S. Hunt has compared a large number with the Huronian rocks of Canada; Dr. A. Törnebohm of Stockholm has made similar comparisons with rocks of Scandinavia, and Herr B. Wapler of Freiberg, with the rocks of Saxony. Prof. Geo. J. Brush has made several analyses and determinations of essential mineral constituents. Prof. R. Pumpelly placed at my disposal his numerous field-notes, made in the Archæan area. Mr. A. A. Julien has minutely described the physical characters of these rocks in Appendix A, vol. ii, of the Michigan Geological Reports, 1873.

From this material the nomenclature given below has been chiefly drawn. As many of the rocks are fine-grained, often aphanitic mixtures of obscure amphibolic and feldspathic minerals, the different kinds and varieties graduating into each other, it is to be expected that similar specimens would often receive different names. This has been particularly the case with the hornblendic rocks, diorytes, diabases, and certain related chloritic schists, also to a less extent with hydro-magne-

* For geographical distribution and structural relations of the copper-bearing rocks, see Brooks and Pumpelly, Am. Jour. Sci., vol. iii, June, 1872; also for Archæan of Michigan, their Map No. 1, Atlas of Michigan Geological Survey, 1873. But little of Northern Wisconsin is mapped in detail.

† Dr. Wichmann is preparing a paper embodying the results of his labors.

‡ Mr. Wright's work was done for the Wisconsin Geological Survey, but the results are not yet published.

sian, argillaceous, and micaceous rocks. An effort has been made to reconcile these different views through the results of the microscopic investigations of the gentlemen above named, as well as by observations in the field, where a fine-grained or altered rock can often be traced through its various transitions to a coarser and typical variety.

The age and distribution of the different members of the Huronian series given in the annexed table are chiefly based on my own observations; use, however, has been made of the notes of Prof. Pumpelly and Mr. Wright, and the publications of Dr. Credner, whose descriptions of the transitions of the various rocks are excellent. The hypothetical scheme of equivalency presented in the table is my own.* That subject was also discussed in a paper entitled, "On the youngest Huronian Rocks south of Lake Superior, and the age of the Copper-bearing Series."†

The thickness of the Huronian series, which are everywhere sharply folded, thus presenting their upturned edges which are often abruptly curved, striking at every point of the compass,—can only be determined with exactness by a protracted study of many sections. Exclusive of the youngest observed member (the granite bed XX, only recently made out), the thickness seems least in the Marquette and western districts, where it is believed not to exceed 6,000 feet, and greatest in the Menominee Region, where it may exceed 12,000 feet. I do not know how Dr. Credner obtained his estimate of 18,000 ft.‡ as the thickness of the sixteen oldest beds of my scheme (the only ones he examined) in the Menominee Region. In one instance, however, owing to his having mistaken cleavage for bedding planes (bed IX), he overlooked at least one synclinal and one anticlinal fold, thus counting the same bed at least three times.

The lithological classification adopted is that given in the second edition of Dana's Manual of Geology, 1875, as best embracing the facts. No other classification of rocks that has come under my notice admits the so-called greenstones among metamorphic rocks, where, following the lead of the Canadian geologists, I would place the diorytes, diabases, and related schists, so abundant in the Huronian area south of Lake Superior, especially in the eastern portion, which is nearest the Huronian of Canada.

* Dr. H. Credner makes my oldest fourteen beds of the Marquette series the equivalents of the quartzyte bed II of the Menominee series. See Zeitschrift der deutschen geologischen Gesellschaft, xxi Band, 1869. His having failed to recognize the upper Huronian, detracts considerably from the weight of this hypothesis.

† Published in the proceding volume of this Journal, page 206.

‡ See his article referred to in the above note.

EXPLANATIONS.

1st. The numbers following many names refer to typical specimens of that rock contained in my Michigan State Collection (see catalogue * in Geological Survey of Michigan, 1873, vol. ii, p. 201), partial duplicate suites of which were furnished the University of Michigan, Boston Institute of Technology, Harvard University, Sheffield Scientific School, the Schools of Mines in New York and Philadelphia, Smithsonian Institution, as well as several other American and foreign institutions. See list in the report named above. The same numbers repeated in the table indicate their stratigraphical position, and the region from which obtained.†

2d. Those rocks marked L have also been observed in the Laurentian system, which has however been but little explored. No Huronian rocks are believed to be identical with those of the copper-bearing series. although some of the greenstones have considerable resemblance.

3d. The Marquette region embraces the important iron-mining district southeast of Keeweenaw Bay; of which Marquette in Michigan is the chief port. About fifty or sixty miles south is the undeveloped Menominee iron region extending into Wisconsin. One hundred and twenty-five miles west of Marquette, on Black River, Mich., and thirty miles farther west, where Bad River crosses the Penokie Iron Range, Wis., the Huronian series is well exposed. See table.

4th. The Roman numerals of the table express the approximate relative age of the twenty beds into which it has been found convenient to divide the Huronian of the Marquette and Menominee regions, numbered from the oldest upward. The equivalency has been extended with less certainty to the Black River and Bad River series, and with still less to the Huronian of Canada. See table.

5th. The names of rocks which have not been observed in the Huronian are usually printed in italics.

6th. The varieties of each kind of rock are arranged in the order of relative abundance, so far as known.

1. FRAGMENTAL ROCKS, EXCLUSIVE OF LIMESTONES.

True quartz-conglomerates are not abundant, but occur in the Middle Huronian, both in the Marquette and Menominee Regions; and in the latter, at the base of the series, is a protogine conglomerate holding pebbles of granite, gneiss, and quartz.

* A supplementary revised and extended descriptive catalogue of this typical suite, now much extended, is in course of preparation.

† The specimen numbers in italics were selected by Dr. Wichmann as possessing the greatest lithological interest. Duplicates have been given to R. Fuess, Berlin, from which I understand he will furnish mounted thin sections.

The Seque with Hypothesis of Equivalency.

NORTH OF LA CANA	IVER SERIES, ebic and Montreal River, HIGAN.	BAD RIVER AND PENOKIE GAP, WISCONSIN.
Geology of Ca	y and **Brooks.**	**T. B. Brooks.**
NOTE.—Important beds of Huronian age, occur near Lake Superior in Canada, cal position is not known t	**SILURIAN.** WITH COPPER SERIES,	**LOWER SILURIAN.** NON-CONFORMABLE WITH COPPER SERIES, Believed to be non-conformable with the following.
	believed to ormably and conceal er Huronian.	Red, gray, coarse and fine grained, *granitic* rock, rarely schistose.
l. White *quartz, chert*		*Greenstone* or hornblende rock, apparently chloritic, (somewhat soft, but tough).
k. Yellow *chert* and	ne with green cherty? specks of jasper and	[Covered about ¼ mile.]
i. White *quartzyte.*	grains of glassy quartz tic.	Clay slate?
	magnetic quartzose flag. g ores.)	

Laminæ of quartz-sandstone occur in magnetite at one locality, and arenaceous quartzytes approaching sandstones at several points. Shaly argillaceous rocks without oblique cleavage, in places highly carbonaceous, are somewhat common; and earthy limonites, having the character of residual deposits, occur in the Marquette Region. These rocks would strictly belong in this class, but as their quantity is comparatively small, and as they are interstratified with and graduate into metamorphic rocks, of which they often appear to be altered forms, they are classed below, where they may stand for the least metamorphosed varieties of the series.

2. Metamorphic Rocks, not Calcareous.

1. *The Mica-bearing Series.*

(1.) *Granite.* (L.) Confined to the youngest bed; also occurs rarely in veins in Lower and Upper Huronian. Common (gray)—*101*. Gneissic. Semi-porphyritic.

(2.) *Pegmatyte.*

(3.) *Granulyte?*—146. Very rare, may exist in the Menominee Region.

(4.) *Gneiss.* (L.) Not abundant, mostly associated with granite. Common (gray)—*102*. Granitic—7. Semi-porphyritic. Compact, related to greenstones—*103*.

(5.) *Mica Schist.* (L.) Abundant, especially in the younger rocks of the Marquette Region. Common, blackish and brownish. Often staurolitic and holding andalusite (Brush)—61. Garnetiferous—108, 56? Quartzose. Hornblendic—*106* (massive, semi-porphyritic?—rare). Green, chloritic—107 (associated with greenstone). Gray, arenaceous, semi-schistose, with mica-scales—*104*. Gneissic—90. Magnetic (L.)—*109*, (rare). Actinolitic—105. The last three varieties have been observed only in the Menominee Region.

(6.) *Mica Slate.* (L).—53?

(7.) *Hydro-mica Slate?*—53, 54. Unctuous-feeling, micaceous rocks, interstratified with iron-ores; they have been called talcoid schists. Sericite—*112*.

8. *Clay Slate or Argillyte.* *a.* Without oblique cleavage, usually in independent beds. Chloritic—114? Carbonaceous (including so-called graphitic varieties)—64, 115. Ferruginous, associated with hematites and limonites. Micaceous, (phyllyte) —111, 56? Feldspathic (arenaceous obscure varieties)—*55?* Pyritiferous. *b.* With oblique cleavage, usually associated with quartzytes or marbles—113, 20. Roofing—81. Novaculyte—10, *12*, 13.

2. *Hornblendic Series.*

(1.) *Syenyte* (containing quartz). (L.)

(1*b*.) *Syenytic Gneiss* (Hornblende Gneiss). (L.)—*117*. Not abundant; rare in the Marquette Region, where it only occurs as a transition variety of greenstone.

(2.) *Hyposyenyte* (quartzless syenyte). Observed only in the Lower Huronian near Marquette, associated with greenstone, into which it seems to graduate. Rich in orthoclase—*116*. Hornblendic—77.

(2*b*.) *Zircon-syenyte.*

(3.) *Dioryte*—75, *118*. Grayish-green, fine to coarse grained. Abundant, especially in the eastern part of the Marquette Region, graduating into hornblendic rocks on the one hand, and, through schistose varieties and diabases (?), into chloritic schists on the other. Hornblendic. Chloritic (schistose)—71? Semi-porphyritic.

(3′.) *Gabbro** ?—69. Confined to bed XV, in the Menominee Region.

(4.) *Hypersthenyte.*

(5.) *Diabasyte.*† Abundant, especially south of L'Anse. This name is often applied by Dr. Wichmann to obscure, fine-grained greenstones which have usually been called diorytes, dioritic schists and chloritic diorytes. Decomposed—99, *120*, 121, 122. Often closely related to one variety of chloritic schist—70. Green, related to dioryte—72, 119, 69. Black, somewhat coarse-grained, highly crystalline, distinct from the other greenstones —*82*. Porphyritic?—83. Micaceous?—31.

(6.) *Hornblende Schist.* (L.) Abundant. Greenish-black, coarse-grained, semi-schistose to massive, graduating into greenstone —18, 22, 30, 88. Eminently schistose, fine-grained, associated with mica schist—128, *125*. Micaceous—29, *127*, 71? Chloritic —76. Calcareous—*124*, rare.

(7.) *Hornblendyte.* (L.?)—*126*. Far less abundant than the schist.

(8.) *Actinolyte*—*129*. Chiefly confined to the Menominee Region. Not abundant.

Anthophyllite Schist‡ (Brush). Quite abundant in the Marquette and Menominee Regions, and always associated with magnetite. Manganiferous—*58*, 59. Quartzose—130. Garnetiferous (eklogyte)—*27*.§

* Dana does not mention gabbro among the metamorphic rocks. As several lithologists agree on the name, and the bed has all of the structural characteristics of the others of this series, I place it here, although Dr. Wichmann regards the rock as diabase.

† From microscopic researches, Dr. Wichmann and Mr. Törnebohme, with whom Prof. Zirkel agrees, regard these Huronian greenstones, the diorytes and diabases, as mostly diabasytes, and consider them of eruptive origin. Regarding them myself as metamorphic, I should have employed the term *meta-diabase*, as lately suggested by Prof. Dana, had it come to my knowledge in time.—Note in letter dated Edinburgh, June 27.

‡ This rock does not occur as a distinct kind in Dana's classification.

§ Dr. Wichmann's microscopic examinations lead him to regard this rock as made up largely of actinolite.—Letter, dated July 27.

(9.) *Pyroxenyte* (augite rock). (10.) *Lherzolyte.* (11.) *Ossipyte.* (12.) *Unakyte.*

3. *Felsitic, Epidotic, and Garnet Rocks* (L. ?),

Having the mass, or base, compact (crypto-crystalline).

No typical rocks of this family have been observed. The nearest kind is a gray, magnetic, amphibolic schist, containing garnets, and closely related to the anthophyllite schists, but which Dr. Wichmann designates eklogyte—*27*.

4. *Chrysolite (or Olivine) Rocks.* Not observed.

5. *Hydrous Magnesian Series.*

(1.) *Protogine* (L.)—3. Not abundant. Quartzyte graduates into this rock in the Marquette Region. In the lowest Huronian of the Menominee Region, holding pebbles of granite, gneiss and quartz—65.

(2.) *Feldspathic Protogine Gneiss?*—147. Has been called graywacke. Occurs only in the Menominee Region in one bed.

(3.) *Talcose Slate*—74. A typical kind has been observed only at Marquette. Unctuous-feeling micaceous and chloritic rocks, often called talcose, are more abundant.

(4.) *Steatyte or Soapstone.*—Said to exist.

(5.) *Chloritic Slate* (schist). (L. ?) Abundant. A hard, very unevenly schistose, gray-green variety, associated with greenstones and hornblendic schists, of which it appears to be an altered or chloritic form, (has received different names)—133, 70? Gray-green, splitting into somewhat uneven thick slates, and related to micaceous and argillaceous rocks—132, *134*. A fissile variety, graduating into clay slate, under which it should perhaps be classed—*55*, 114? Dark-green, pure, massive, containing pseudomorphs after magnetite, garnet, and amphibole, occurs in iron-ore—*89*. Ferruginous. Micaceous, in greenstone. Compact, magnetic, conchoidal fracture—28?

(6.) *Chloritic Argillyte.* A slate termed chloro-argillaceous, is very abundant in the Menominee Region—114. Often carbonaceous.

(7.) *Serpentine*—*78*. Very rare. Apparently altered greenstone, and having somewhat of an eruptive character.

(8.) *Ophiolyte.* (9.) *Schilleryte.*

6. *Hydrous Aluminous Rocks.* Not observed.

7. *Quartzose Rocks.*

(1.) *Quartzyte.* Very abundant, graduating into marble on one hand, and into protogine on the other, containing beds of clay slate with oblique cleavage. White to light-gray, massive, arenaceous, often with glassy grains, occasionally with ripple-marks, and on Black River showing the false stratification

of sandstone—8, 21, *137*. Micaceous quartz schist, often conglomeritic—*140*, 50, 51. Quartz conglomerate (see remarks under "Fragmental Rocks"), associated with and constituting a variety of the above—145. Chloritic arenaceous—138. Blue-gray, arenaceous, weathering to a brown sandstone—*139*. Banded magnetite and arenaceous quartz schist—52. Micaceous and specular iron—32, 33, 49. Limonitic—26. (The three last varieties are also classed under Iron-ore rocks.) Calcareous.

(2.) *Siliceous Schists*, compact, often slaty, generally ferruginous, and graduating into siliceous flaggy iron-ores, are abundant. Poor in iron. Rich in iron (siliceous flag ores)—23, 36, 68. (See Iron-ore rocks.)

(3.) *Chert.* A flinty rock, flaggy to slaty, between siliceous schist and jasper, abundant only in the middle of the Black River series. Sometimes brecciated—85, 84? Lydianstone—very rare.

(4.) *Itacolumyte.*

(5.) *Jasper Rock.* An impure reddish variety, banded with specular ore, is abundant in the Marquette Region—*37*. Better characterized, banded, often ferruginous, jaspers occur with chert in the Black River series. Sometimes brecciated—84, 85?

(6.) *Buhrstone.*

8. *Iron-ore Rocks.*

Magnetites, *Hematites* (usually specular), *Limonites*, and related ferruginous rocks are very abundant in the Middle and Lower Huronian, especially in the eastern portion of this Huronian area, while they are comparatively rare in the same series in Canada. At least seven out of the twenty beds of the Marquette Region are ferruginous, and four have produced first-class ores. The rich specular hematite, which is so far most extensively mined, is mostly confined, however, to bed XIII, in which the richest magnetites also occur. There is less iron in the Menominee Region, and still less and of lower grade, so far as observed, in the Black River and Bad River series.

The magnetites and specular hematites graduate into each other through martite, which is abundant. They are also sometimes interstratified in the same bed, although seldom in juxtaposition. Nearly the same may be said of the hematites and limonites, but not of the latter and magnetites, which are never found together. These facts support the hypothesis that these ores, whatever their origin, were once all magnetites, part of which were afterward oxidized to hematites, and part of these in turn into limonites.

No rocks are embraced below which do not occur in considerable beds. To include all of them I have found it necessary to considerably expand the skeleton given by Professor Dana,

and to add limonites, which are so closely related to the others that it was not attempted to separate them here.

Iron-oxide, except as disseminated grains of magnetite and in a few instances in small unworkable beds, is entirely absent from the Laurentian and Copper-bearing series of the Archæan south of Lake Superior, while in Canada the largest deposits are reported as occurring in the Laurentian. Titaniferous iron-ore, so abundant in the Archæan of Canada and northern New York, has not been observed south of Lake Superior. In several hundred analyses of these ores,* I have only once seen "a trace" of titanium reported. Franklinite has not been observed.

(A.) *Magnetites and Magnetic Quartzose and Amphibolic Rocks.* Most abundant and, except the amphibolic kinds, found only in typical forms in the western part of the Marquette Region.

a. *Rich in iron* (*iron-ores*).

*a*1. Blackish granular magnetites, massive to semi-schistose, fine to coarse grained, compact to friable—39, 40, 41, 42.

*a*2. Cryptocrystalline, compact, tabular, schistose, sometimes containing actinolite—17 ?

b. *Poor in iron, rich in quartz,* (*magnetic rocks*). *Most abundant in the Marquette Region, especially in the western part; also abundant in the Penokie* (*Bad River*) *series.*

*b*1. Banded, arenaceous quartz and magnetite layers—52.

*b*2. Intimate mixtures of magnetite (with hematite) and quartzose matter, often cherty. Magnetic siliceous schist (flag ore)—23, 15. Both varieties graduate into ferruginous quartzytes.

c. *Ferruginous rocks, rich in amphibole,—the iron-oxide mostly magnetic.* (*Here are embraced such anthophyllite schists as are rich in iron.*) *Tolerably abundant in the Menominee Region.*

*c*1. Banded quartzose, amphibolic (mostly anthophyllitic, according to Brush), magnetic schists—130, 17. According to Dr. Wichmann the iron-ore at Penokie Gap is a related variety —148.

*c*2. Manganiferous anthophyllitic magnetite schists—*58*. Only in western part of the Marquette Region, constituting bed XVII.

*c*3. Garnetiferous anthophyllitic magnetite schist (eklogyte) —*27*. Only in one bed in the Marquette Region.

(B.) *Specular Hematites, Martites, and siliceous, jaspery, argillaceous Hematitic rocks.* Most abundant and typical in the eastern part of the Menominee Region.

a. *Rich in iron.*

*a*1. Granular, massive to semi-schistose, specular hematite and martite. Usually contain a little magnetite. Not so abundant as the magnetites of corresponding structure—5.

* See my Michigan Report, vol. i, chap. x, 1873.

*a*2. Chloritic, semi-schistose, specular ores, not abundant, —43.

*a*3. Specular-iron schists, often slaty, and passing into micaceous-iron varieties (the most abundant form of hematite)—38, 45, 47, 48.

*a*4. Micaceous-iron slaty schist; graduates into the last, *a*3. When interstratified with magnetic ore, it usually contains magnetite—46, 49.

*a*5. Kaolinic specular schist—2, 44. Rare and observed only in the eastern part of the Marquette Region.

*a*6. Purplish to pigeon color, shaly to sandy, generally rich in iron, dull specular ore—136, 67. Confined to the eastern part of the Menominee Region.

b. *Quartzose specular Hematites, poor in iron, poor in quartz. Abundant. Graduates into hematitic quartz schist.*

*b*1. Banded, micaceous-iron, quartzose schist—16, 32, 33. Abundant in the Marquette Region.

*b*2. Banded specular-iron with jaspery quartz ("mixed ore"), the laminæ often plicated and faulted to the extent sometimes of producing a breccia. Abundant with specular ores in the eastern part of the Marquette Region—*37*. Similar but more jaspery and less ferruginous rocks occur in the Black River series—84.

*b*3. Intimate mixture of specular hematite (often magnetic) with quartzose matter, often cherty. Hematitic siliceous schist (flag ore). Very abundant—68, 19, 36. Sometimes contains grains, apparently of decomposed garnets (bird's-eye ore)—6.

c. Hematitic argillaceous, hydro-magnesian and micaceous schists, sometimes graduating into limonitic varieties, and usually associated with rich iron-ore. Poor in iron; generally diffused, but not abundant. Included under varieties of clay and chloritic slate and mica schist.

(C.) *Limonitic Quartzose Ores and Rocks, often containing hematite and manganese.* Usually some shade of dull brown, generally soft and more or less earthy. Often contain ochre and kaolin (Brush), and probably turgite. Appear to be of the nature of residual deposits, from the partial dissolving out of the silica and the hydration of the iron of quartzose hematites.

a. Rich in iron ("soft hematite ores"). Most abundant in the Marquette Region, although absent from the magnetic district about Lake Michigamme. Also found in the Menominee Region.

*a*1. With little or no manganese—34, 35. A hard, red variety, rich in iron, and containing four per cent of water occurs in the Menominee Region—135.

*a*2. Richer in manganese (specimens of pure pyrolusite being sometimes found)—24, 25.

b. Poor in iron, rich in quartz, often ochrey. Graduates into limonitic quartz schist. A very siliceous variety of the two prevailing kinds in which a less proportion of the silica seems to have been dissolved out—26, 57. Generally diffused but not abundant. Was not observed in the Penokie series.

3. CALCAREOUS ROCKS.—CARBONATES AND SULPHATES.

1. *Uncrystalline Limestones.* Not observed.
2. *Crystalline Limestone.*

Tolerably abundant, especially in the Menominee Region. Usually dolomitic. In the Marquette Region it is always associated with quartzyte, and contains interstratified beds of clay slate (novaculyte) with oblique cleavage.

(1.) *Granular Limestone*—rare. Ferruginous—97; very rare, probably a vein. Brown, micaceous—144; observed at one point in the Marquette Region.

(2.) *Dolomyte and Dolomitic Limestone.**—Most if not all the limestones in beds contain more or less carbonate of magnesia.

The prevailing variety is light-grayish, sometimes mottled, fine-grained, semi-schistose, often containing quartzose laminæ, which project on weathered surface (ribbed)—9, 66, *143*. A crystalline, medium to coarse grained massive variety, free from quartz:—white in the Menominee Region, where it is most abundant; sometimes salmon-colored in the Marquette Region—11. White crystalline dolomyte, holding numerous crystals of tremolite, and, according to Dr. Wichmann, of wollastonite (142), occurs in the northeast part of the Menominee Region.

Siliceous; besides the variety banded with quartz laminæ, is one in which the quartz exists in grains, appearing on the weathering surface almost like sand,—*141*. It occurs midway between the Marquette and Menominee Regions. Argillaceous, in thin beds, at Lake Antoine, Menominee Region.

(3.) *Consisting of Sulphate of Lime.* Not observed.

4. IGNEOUS OR ERUPTIVE ROCKS.

(Including those metamorphic rocks which in a plastic state have been forced into adjacent cracks, thus taking the form of eruptive rocks).

1. *Feldspathic Series.*

(1.) Granite dykes or veins have been observed only in the Lower and Upper Huronian of the Menominee Region. Red ferruginous granite in iron-ore at two points—96. Gray granite

* Dr. Credner erroneously assigns certain dolomytes and conglomerates to the Laurentian. See Zeitschrift der deutschen geologischen Gesellschaft, xxi Band 1869, p. 516. Marbles, so abundant in the Laurentian of Eastern Canada have not as yet I believe been observed in that system as developed south of the lake.

in the hornblende and mica schists of bed XIX, at the contact with the overlying granite bed.

Granite dykes are very numerous in the Laurentian.

2. *Hornblende and Pyroxene Series.*

Some geologists would include here a considerable portion of the bedded greenstones embraced under metamorphic rocks.

"Trap"-dikes in a bed of magnetite occur at the Washington mine. At a few other points very small ones have been seen. Black, fine-grained, massive, hard, tough. Has been called doleritic, dioritic, and, by Dr. Wichmann, diabase. (Has but little resemblance to the bedded rocks so-named)—*79*, 94. The greenstone dikes, sometimes of great thickness, so numerous in the Laurentian, are not so fine-grained and are more dioritic in character.

3. *Hydrous Magnesian Schistose Rocks.*

These are found in dyke-like masses crossing quartzytes, iron-ores, and greenstones, sometimes apparently formed from the abraded material of the walls of a fault,*—73. Sometimes the rock is erratic, as in the case of the soft chloritic? schist dyke in massive quartzyte at the northeast corner of Teal Lake. Not observed in the Laurentian.

Dresden, Saxony, Dec. 21, 1876.

ART. XXVI.—*Seventh Catalogue of New Double Stars;* by S. W. BURNHAM.

THE double stars in the following list have been discovered during the past year with the Clark & Sons 6-inch refractor previously used in these observations. The six catalogues preceding this will be found respectively in Monthly Notices of the Royal Astronomical Society for March, May and December, 1874, June and November, 1875, and Astronomische Nachrichten. No. 2062. The reference number in the first column is continued through the series.

Four pairs from the old double star catalogues have been found to be again more closely double. These are:

σ 39
H 4935
ɰ III. 113 (=Σ 2630 *rej*)
H 1489

Through the kindness of the distinguished observer, Baron Dembowski, I am enabled to attach his careful micrometrical measurements of a few of these objects.

* Faults of any great magnitude are rare in the Huronian.

No.	Designation.	R. A. 1880.	Decl. 1880.	Pos.	Dist.	Mags.
		h m s	° ′	°	″	
391	B.A.C. 10	0 3 14	−28 39	110·±	0·7 ±	6·0...6·0
392	B.A.C. 46	0 10 31	+60 52	...	20· ±	6.0..11·8
393	L 291	0 12 12	−21 48	30·±	0·5 ±	7·0...9·0
394	L 678	0 24 14	+46 52	300·±	1· ±	8·0...8·0
395	Ceti 82	0 31 9	−25 26	135·±	0·5 ±	6·0...6·0
396	B.A.C. 282	0 56 13	+60 26	85·±	1· ±	6.0..11·0
397	L 1943	1 0 53	+46 12	160·±	10· ±	8·0..10·5
398	O². Arg 1200	1 4 52	+47 10	60·±	2· ±	8·0...8·0
399	Ceti 211	1 21 46	−11 31	301·2	1·49	6·5..10·0
400	W¹III. 50	3 5 18	− 4 16	45·±	15· ±	7·0..11·5
401	W¹III. 830	3 44 10	− 1 52	260·±	4· ±	7·0..11·0
402	W¹IV. 318	4 17 3	− 1 33	75·±	5· ±	8·5..10·5
403	W¹IV. 379	4 19 18	− 2 20	100·3	2·00	7·0...8·5
404	Arg(8°) 805	4 49 51	+ 8 58	113·4	1·49	9·0...9·5
405	W¹V. 1045	5 42 22	−13 34	150·±	10· ±	8·5..11·0
406	W¹V. 1068	5 43 1	−13 28	260·±	8· ±	9·0..12·0
407	W¹VIII. 1159	8 45 50	− 6 20	160·±	6· ±	8·0..10·0
408	R 2231	8 48 58	+63 54	350·±	2· ±	7·0..10·0
409	W¹VIII. 1383	8 54 55	− 8 43	180·±	10· ±	8·0..10·0
410	B.A.C. 3127	9 4 30	−25 19	160·±	1·5 ±	7·0...9·0
411	Lac 4360	10 30 25	−26 3	310·±	1·3 ±	7·0...9·0
412	L 22722	12 2 10	−17 55	160·±	1·5 ±	8·0...9·5
413	Lac 5686	13 42 15	−27 46	110·2	77·7	6·8..10·0
414	Centauri 315	14 34 42	−30 25	160·±	1· ±	6·5...6·5
415	O². Arg 15675 A and B	15 44 50	+65 57	336·8	12·72	8·5..11·5
	A and C			357·6	30·82	12·0
416	Scorpii 155 A and B	17 10 46	−34 51	240·±	1·8 ±	6·0...8·5
	A and C			130·±	15· ±	10·0

391. This is κ′ Sculptoris of some of the star catalogues.

393. Very difficult.

395. B.A.C. 160, magnitude 6.

396. A pair of the most extraordinary difficulty, very close and unequal. Not an easy test for a large aperture. Heis gives this as naked-eye star.

397. There is but little doubt this is the pair observed for H 2015, but error of 1° in Herschel's declination. There is nothing in his place.

399. The small star was suspected in Dec., 1873, but not verified until two years later. Measured by Dembowski (1876·07). There is a very distant companion in the direction of 67° which makes the pair σ 39.

402. Found in looking for Σ 547, the companion of which was invisible; so noted by Dembowski in 1865.

403. Measures by Dembowski (1876·07).

404. Found in verifying a suspected error of 1^m R. A. in OΣ 90. Measures by Dembowski (1876·07.)

405. This and the next following were found in looking for Σ801 *rej.*

408. In Argelander $6{\cdot}7^m$.

411. A naked-eye star according to Heis.

413. Not properly a double star, but inserted for its remarkable red color. Dembowski calls it "perfect blood red." Most of the red stars of this class are smaller, and not so strongly marked. The small star appeared decidedly blue. My approximate measures of angle and distance. Not in Schjellerup's Catalogue of Red Stars.

415. Measures by Dembowski (1876·39).

416. A and C make the double star, H 4935. Close pair easy, although very low.

No.	Designation.	R. A. 1880.	Decl. 1880.	Pos.	Dist.	Mags.
		h m s	° ′	°	″	
417	L 32929	17 52 13	+39 27	270·±	1·5±	8·0...9·5
418	O². Arg 17847	18 1 28	+64 26	240·±	10· ±	8·5..11·5
419	L 34259	18 25 42	− 7 55	40·±	1·5±	8·0...9·5
420	W²XVIII. 722 A and B	18 25 53	+37 5	280·±	1·5±	8·5..10·0
	A and C			200·±	20· ±	11·0
421	W²XVIII. 1452 A and B	18 48 3	+43 15	270·±	1· ±	8·5...9·0
	A and C			230·±	30· ±	9·0
422	O¹. Arg 19281	19 7 34	−18 16	50·±	8· ±	8·5..11·5
423	O¹. Arg 19560	19 20 17	−29 44	110·±	1·2±	8·0...8·5
424	W²XIX. 676	19 23 5	+35 49	60·±	2·5±	8·5..10·0
425	L 38087	19 52 15	+19 58	241·1	1·33	8·5...8·7
426	O². Arg 19938	19 59 13	+54 18	140·±	6· ±	8·0..10·0
427	O². Arg 19952	19 59 28	+54 20	160·±	3· +	8.0..10·0
428	Arg(12°)4226	20 1 7	+12 36	346·4	0·52	7·2...8·0
429	L 38521 A and B	20 1 27	+35 27	30·±	7· ±	7·5..11·5
	A and C			301·0	10·79	10·0
	A and D			90·±	25· ±	11·0
	A and E			28·2	36·52	9·0
430	Arg (35°) 4008 A and B	20 6 48	+35 28	30·±	1· ±	9·0...9·0
	A, B and C =H 1489			55·1	20· ±	9·5
431	W²XX. 530	20 15 25	+35 53	240·±	0·5	8·0...8·5
432	W²XX. 698	20 20 13	+35 23	220·±	1·2	8·0..10·0
433	Arg (50°) 2399 A and B	20 23 36	+55 55	220·±	6· ±	9·0..11·0
	A and C			250·±	20· ±	10·5
434	W²XX. 941	20 28 4	+41 27	100·±	1·2±	8·5...9·0
435	L 39867	20 33 14	+14 35	112·5	2·95	8·0..11·0
436	O².Arg. 23612	22 6 44	+57 21	340·±	15·±	8·0..10·8

417. In the field with Σ2246.

419. Found in looking for one of Herschel's suspected pairs, H 5496.

425. Measured by Dembowski (1875·72). He has detected a very minute companion about 10″ following, which I failed to see.

426. In the same field with No. 427, the two forming with a third 8^m star a small triangle.

428. Close and difficult. The wide pair of small stars in the field is H 1476. The large star is rather strangely wanting in all the other Star Catalogues I have access to. Measures by Dembowski, two observations (1875·73).

429. The companions B and D are new. A, C and E make H III. 113= Σ 2630 *rej.* = Sh 314. Given with Herschel's measures (1783·7). In a splendid field.

430. As a wide pair this is H 1489, entered by Herschel, 236°·3 : 13″± : 9–10..10. There is probably an error of 180° in his angle, as the preceding star is obviously the largest, and so in Argelander who noted the magnitudes as 9·3 and 9·5. By a rough measure I found 55°·1, showing no material change has occurred since 1828. From the faintness of the components, the close pair is a very difficult object under ordinary conditions.

431. Very difficult.

433. Found in trying to identify H N. 89.

435. About 26′ *sf* *β* Delphini. Measures by Dembowski (1875·76).

Chicago, July 27, 1876.

ART. XXVII.—*An account of a New Meteoric Stone that fell on the 25th of March,* 1865, *in Wisconsin, identical with the Meno-Meteorite;* by J. LAWRENCE SMITH, Louisville, Ky.

THE Wisconsin meteorite, which fell on the 25th of March, 1865, and is one of much interest, attracted no attention at the time of its fall outside of the immediate neighborhood where it was observed, a fact due to the comparatively sparsely inhabited condition of the country. It was brought to my attention only a few months ago by one living in the region not far from where it fell. He sent me a small fragment that had been presented to him, and so similar was it in its appearance to the Meno-Meteorite that fell in 1861, that, not having heard of any fall at the period when this one was said to have been found, I considered it at first a fragment of that rare meteorite which had found its way to that part of the country. But on further inquiry and search I was soon satisfied that it was a piece of an undescribed meteorite; I have designated it the *Claywater* meteorite.

The following is the account I have been able to gather in relation to its fall.

In Vernon County, State of Wisconsin, about lat. 43° 30′, long. 91° 10′, at nine on the morning of the 25th of March, 1865, a body was seen by several persons passing rapidly through the atmosphere, accompanied with a loud rumbling noise. It was luminous and showed flashes of light. Its course was from northwest to southeast, and it exploded at a supposed altitude of four miles. At the time that the small fragments were thrown off from the main body, a noise like the rolling of musketry was heard. The main body seemed to have a rotary motion, making about one revolution in two seconds of time.

The observer from whom the above facts were obtained, thinks that the main body did not fall but passed into space.

No fragments were found until about five days after the fall, when two were discovered, weighing in all fifteen hundred grams. The curves of the surfaces of these fragments would indicate that they had pertained to a mass having a diameter of about thirty centimeters. No data were obtained by which to calculate its velocity, but the observer already referred to says that it was variously estimated from fifteen to twenty-five miles per second. Of the two fragments that fell, one has been lost or destroyed; the other has been placed in my possession by Mr. Claywater, who made the observations already recorded, and to whom we are indebted for the preservation of what we have of this interesting meteorite; for it differs in its physical aspects from any yet observed in this country.

The fragment in my possession, and which is all that has been recovered from this fall, weighed seven hundred grams; about one-third of the surface was covered with a thick, dull black crust; the fractured surfaces are quite granular, and its structure porous; it belongs to the hard variety of meteoric stones. Examined with a glass the grains are of a dirty green color with a greasy aspect, and in some places have a globular structure. Particles of iron are disseminated abundantly through the mass, and particles of troilite are also visible.

Its specific gravity is 3·66 and it is composed of:

Stony matter	78·33	per cent.
Metallic particles	17·07	"
Troilite	4·60	"
	100·00	

The stony matter treated with aqua regia furnished:

Soluble matter	47·20	per cent.
Insoluble matter	52·80	"
	100·00	

The composition of these two portions are:

	Soluble.	Insoluble.
Silica	32·55	57·41
Protoxide of iron	30·40	9·50
Alumina	trace.	4·00
Magnesia	35·80	22·80
Lime		3·70
Soda	·60	2·01
	99·35	99·42

The metallic particles, completely separated from the stony portion, are composed of:

Iron	92·15
Nickel	7·37
Cobalt	·28
Copper } very minute quantity;	
Phosphorus } not estimated.	99·80

In regarding the above analyses, it is very evident that the meteorite is made up of:

Bronzite, with probably a little anorthite	41·35
Hyalosiderite (olivine)	36·98
Nickeliferous iron	17·07
Troilite	4·60

As I was not able to find any analysis of the Meno (Alt. Strelitz Mecklenburg) meteorite, which fell Oct. 1st, 1861, at midday, and as the physical aspects of the one just described

were so strikingly similar to those of the Meno, I was interested to ascertain the mineralogical and chemical relations of the two.

An examination was made of this last meteorite, the result of which is placed in contrast with those obtained from the Claywater meteorite.

	Claywater.	Meno.
Stony matter	78·33	77·76
Metallic particles	17·07	18·00
Troilite	4·60	4·24
	100·00	100·00
Stony part, soluble	47·20	48·70
Stony part, insoluble	52·80	51·30
	100·00	100·00
Stony part, analyzed as a whole.		
Silica	44·98	44·70
Protoxide of iron and alumina	21·95	22·26
Magnesia	29·30	28·97
Lime	1·80	1·85
Soda	1·32	1·20
	99·35	98·98
Metallic particles.		
Iron	92·15	91·86
Nickel	7·37	7·53
Cobalt	·28	·13
Copper and phosphorus	traces in both.	
Specific gravity	3·66	3·65

It will be observed that the specific gravity of the Meno here given, is lower than that stated in Poggendorf's Annalen, cxvii, 637, it being there given as 4·1; but this must have been taken with a fragment containing some large particles of iron. My determination was made on two good average fragments, broken from a very fine specimen sent me by the late Wm. Nevill, of London, which were examined in my usual method, viz: after weighing the fragment to immerse it in water contained in a small vessel, and, placing this beneath the receiver of an air pump, thereby extracting all the air from the surface and cavities, and completing the process in the usual way.

In regarding the above comparative statement of the composition of these meteorites, it will be seen that the compositions of the two as made out by me do not differ more than those of two fragments of the same meteorite, while they both differ in their *physical aspects* from the ordinary type of meteorites, and, in fact, they have few or no parallels in the collections of these bodies; there are certainly none in mine, embracing stony meteorites representing over one hundred falls.

ART. XXVIII.—*Five new Variables, and a new Planet, found at the Litchfield Observatory of Hamilton College;* by C. H. F. PETERS.

RECENTLY the variability has been ascertained by me of stars in the following positions:

Right Asc.			Decl.		Max.	Min.
h.	m.	s.			mag.	
10	16	32	+14°	42′·7	10	∞
15	13	21	−19	53 ·0	6	10
16	0	19	−21	8 ·9	10	∞
20	6	15	−22	24 ·0	11	∞
21	0	32	−21	54 ·6	10	∞

The limits of magnitude given are gathered from only occasional notes taken during the later years. For fixing them more accurately, and also for determining the times of periodicity, more systematic and continuous watching would be required.

The positions refer to the equinox of 1860, which is the epoch of my manuscript charts.

A new planet, 11th magnitude, was found here last night (Aug. 9), of which I give to-day only the approximately reduced position:

Aug. 9, 1876. $10^h\ 34^m\ 27^s$.

$\alpha(165) = 21^h\ 27^m\ 42^s$. $\delta(165) = -10°\ 0'\ 18''$.

The motion is nearly parallel to equator, perhaps slightly southward, 56^s in right ascension.

ART. XXIX.—*On the Relation of Franklinite to the Spinel Group of Minerals;* by GEORGE H. SEYMS. (Contributions from the Sheffield Laboratory, No. XLI.)

THE amount of iron in Franklinite, as shown by numerous determinations that have been made in the Sheffield laboratory, is subject to considerable variation. To determine whether this variation affects the general character of the mineral, and to supplement the recent investigations upon its composition and relation to the Spinel group, was the object in making the following analyses.

The first experiments were made on perfectly formed crystals, in a matrix of limestone, from Mine Hill. The analyses gave results which may be best expressed as follows:

	I.	II.	Mean.
SiO_2	·17	·17	·17
Fe_2O_3	63·42	63·38	63·40
Mn_2O_3	4·44	4·44	4·44
MnO	10·39	10·53	10·46
ZnO	23·11	23·12	23·11
	101·53	101·64	101·58

The relation of the metals to the oxygen, taking the mean of the two analyses, is given in the subjoined statement.

	Metals.	Oxygen.	
Fe_2	44·38	19·02	20·37
Mn_2	3·09	1·35	
Mn	8·10	2·36	6·92
Zn	18·55	4·56	

Dividing the amount of each element by its atomic weight gives as the ratio of the metals to the oxygen, R : O :: 3 : 3·999 $=R_3O_4$ nearly, or an oxygen ratio of the protoxides to the sesquioxides of 1 : ·981 or nearly 1 : 1, which corresponds to the formula of the Spinel group, $(R_2O_3+RO=R_3O_4)$.

The state of oxidation of the manganese here given was determined by solution of the mineral in HCl, and estimation of the clorine liberated, according to Bunsen's iodine method. Two experiments gave chlorine equivalent to ·47 per cent and ·43 per cent of oxygen, mean ·45, which requires the presence of 4·44 per cent Mn_2O_3.

The analyses following were made on a sample taken from an aggregation of imperfect crystals from Sterling Hill. While the crystals in the former case were but very feebly magnetic, these were strongly so, though they showed no signs of magnetite as an admixture.

	I.	II.	III.	IV.	Mean.
SiO_2	·08	——	——	·08	·08
Al_2O_3	·65	·65	——	..	·65
Fe_2O_3	67·43	67·50	67·32	67·42	67·42
FeO	15·68	15·62	——	——	15·65
ZnO	6·79	6·81	6·76	6·75	6·78
MnO	9·71	9·47	9·51	9·44	9·53
	100·31	100·16	99·97	99·99	100·12

This gives from the mean of the four analyses:

	Metals.	Oxygen.	
Al_2	·35	·30	20·53
Fe_2	47·19	20·23	
Fe	12·17	3·48	6·97
Zn	5·44	1·34	
Mn	7·38	2·15	

Deducing from this the atomic ratio of the metals to the oxygen we have as a result R : O :: 1 : 1·331 or as 3 : 3·994 = R_3O_4, and we find the oxygen ratio of the protoxides to the sesquioxides to be as 1 : ·981 or nearly 1 : 1.

The amount of iron protoxide shown in these results was found directly in the usual way by potassium permanganate.

As it has been stated that some varieties of franklinite give with HCl a solution containing $FeCl_2$, and at the same time evolve chlorine, this variety was quantitatively tested by Bunsen's method with a negative result. Careful experiment failed also to show any iron protoxide in the variety first analyzed. In both cases, therefore, the total amount of oxygen may be said to be fairly determined.

The results of these analyses give in both cases a ratio very nearly corresponding to that of spinel, notwithstanding the great differences in the relative amounts of the iron, zinc and manganese.

April 6th, 1876.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Thermic formation of Ozone.*—Berthelot has studied thermo-chemically the formation of ozone. Pure and dry oxygen was passed through a tube, where it was subjected to the influence of the silent electric discharge, and then into a calorimetric flask containing 500 c.c. of a solution of arsenous acid in hydrochloric acid, previously titered. At the end of twenty to thirty minutes, six to nine liters of oxygen had passed through the calorimeter, and its temperature had been raised one-third of a degree. By passing the oxygen current alone through the apparatus under the same conditions for an equal time, both before and after the experiment, the thermal data were rendered complete. The arsenic solution was treated with a graduated solution of permanganate in excess, and then titered back with a standard solution of oxalic acid. In this way the amount of arsenous acid oxidized and therefore the amount of ozone absorbed, was determined. In two experiments, the oxygen absorbed was 30·3 and 51·9 milligrams, corresponding to 90·9 and 155·7 milligrams of ozone; the heat set free being 118·2 and 223·7 calories respectively. Whence for one molecule, 48 grams, the heat is equal to +68·8 calories. Subtracting from this the heat produced in the oxidation of a molecule of arsenous acid, determined by Favre and by Thomsen to be +39·2 calories, we have +29·6 calories for the heat set free by conversion of one molecule of ozone into oxygen, and of course −29·6 calories in the reverse

process. This value is one-half greater than that given in the formation of the same volume of nitrogen monoxide or of chlorine monoxide, in both of which the value is −18. It is two-thirds of that given in the formation of nitrogen dioxide −43·3. In the three cases of direct synthesis of compound gases under the influence of electricity, the author finds:—

$O_4+O_2=(O_3)_2$ (4 volumes)—29·6 cal. (spark or silent discharge).
$N_2+O_4=N_2O_4$ (4 volumes)—24·3 cal. (spark).
$C_4+H_4=(C_2H_2)_2$ (4 volumes)—64· cal. (electric arc),—

an obvious proof of the function of electricity in chemical synthesis. Ozone therefore is a body in whose formation heat is absorbed, and the activity of which is due to this heat, which is again set free when it combines. It is thus a magazine of energy stored up under the influence of electricity. This is notable when it is remembered that it is condensed oxygen; condensation generally setting free heat.—*C. R.*, lxxxii, 1281, June, 1876.

G. F. B.

2. *On Hydrogen antimonide or Stibine.*—Owing to the difficulty of freeing stibine from hydrogen, and to the fact that it spontaneously decomposes even at ordinary temperatures, its exact composition has never been ascertained. JONES has examined the question anew and has obtained results which are closely approximate. The method he preferred for preparing the gas was to allow a strong solution of antimony in hydrochloric acid to drop on a considerable bulk of zinc either granulated or in powder. Chancing to observe the ready action of the gas on sulphur, according to the reaction

$$(SbH_3)_2+S_6=Sb_2S_3+(H_2S)_3$$

the author made use of the fact in order to analyze it. The dry gas was passed through weighed U-tubes containing sulphur, then through a calcium chloride tube, and then through a strong solution of copper acetate. The apparatus being placed in sunlight (the reaction not taking place in the dark) it was found that a secondary reaction took place between the stibine and the hydrogen sulphide $(SbH_3)_2+(H_2S)_3=Sb_2S_3+(H_2)_6$. By screening the empty portions of the tubes the quantity of sulphide thus formed was lessened; and by allowing for it, the amount of hydrogen combined with 122 parts (one atom) of antimony was found to be in two experiments, 3·34 and 3·13 respectively; whence the author concludes upon SbH_3 as the correct formula of stibine. He found the reaction of this gas on sulphur so delicate a test for the presence of light that he made some photometric and photographic experiments with it. It is an excellent test for antimony.—*J. Chem. Soc.*, clxi, 641, May, 1876. G. F. B.

3. *Compounds of Columbium and Tantalum with Nitrogen and with Carbon.*—JOLY has made a series of experiments on the compounds formed by reducing at high temperatures oxides of columbium and tantalum in carbon crucibles. A mixture of

columbic oxide, sodium carbonate and pure carbon thus heated to whiteness, affords a crystalline mass of an olive color and friable. Heated to the temperature of fusion of nickel for six or seven hours, long violet-gray brilliant needles are obtained, which analysis showed to be a mixture of columbium carbide and nitride. The product formed at the temperature of fusion of steel contained $\frac{2}{3}$ of a molecule of the latter to one of the former; when heated for a longer time $\frac{1}{3}$ of a molecule; and that formed at the temperature of fusion of manganese, $\frac{1}{5}$ to 1. Tantalic acid thus treated acts similarly except that the carburation may be carried higher; one product, of a beautiful bronze-yellow color, obtained at the temperature of melted steel, containing only 0·7 per cent of nitrogen. —*Bull. Soc. Ch.*, II, xxv, 506, June, 1876. G. F. B.

4. *New mode of effecting the Substitution of Chlorine or Bromine in Organic Compounds.*—DAMOISEAU has called attention to the remarkable way in which carbon facilitates the introduction of chlorine and bromine into organic compounds. The form of carbon he prefers is obtained by calcining a mixture of dried blood and potassium carbonate, and subsequent washing and igniting. If the animal charcoal thus prepared be placed in a tube heated to 250° to 400°, and a mixture of chlorine with, for example, ethyl chloride gas be passed through it, abundant white fumes of hydrochloric acid appear, and oily drops collect on the walls of the tube. By varying the proportion of the two gases, monochlorinated, dichlorinated, trichlorinated, tetrachlorinated or finally perchlorinated ethyl chloride may be obtained singly and almost pure. Other chlorides act similarly. With bromine the effect is even greater. It is remarkable that if the tube be filled with pumice, wood charcoal, alone or platinized, or even with platinum sponge itself, the effect is insignificant.—*C. R.*, lxxxiii, 60, July, 1876. G. F. B.

5. *On Physical Isomerism.*—In studying nitrometachlornitrobenzene, LAUBENHEIMER has discovered an excellent example of physical isomerism. To prepare this substance, metachlornitrobenzene was treated with a mixture of fuming nitric and sulphuric acids with the aid of heat. On pouring the whole into water, a yellow oil fell down, which almost entirely solidified to a crystalline mass on cooling. On investigation it appeared that this nitrometachlornitrobenzene existed in four distinct modifications, physically isomeric, three of which were solid, the other liquid. The first or α-modification is obtained by dissolving the crude product in warm alcohol and allowing it to cool. An oil separates at first, in which after some time crystals appear which by repeating the operation become large thick prisms. Any of the other forms when melted, crystallize in this form on introducing a fragment of it, as the liquid cools. The crystals are monoclinic twins with a well-defined cleavage, in which $a:b:c=1·8873:1:0·9810$ and $\gamma=114°\ 14'$. The plane of the optic axes is perpendicular to the plane of symmetry. Angle between them 45° 31′ for Na light. Double refraction strong and negative. Fusing point

36·3°. The second, or β-modification is obtained by fusing the first completely at a temperature of 39° to 40°, and allowing to cool. Long concentric groups of thin prisms are in this way obtained. Crystals of α, after five weeks, yield β on crystallization from alcohol. Either of the varieties fused and allowed to cool yield β on introducing a crystal of this form. It also is monoclinic but without cleavage. The axis-ratio $a : b : c = 0·6249 : 1 : 0·5600$ and $\gamma = 91° 27'$. Its fusing point is 37·1°. The third or γ-modification crystallized from the aqueous solution into which the mixture was poured in preparing the substance. It is also the most permanent form of them all, both α and β crystals becoming turbid in twenty-four hours and being completely converted into γ in a few weeks. The crystals are orthorhombic, show a distinct cleavage, and have a moderate, positive double refraction. The angle between the optic axes is for sodium light 47° 17'. The fusing point is 38·8°. The fluid modification was obtained by heating any of the other forms to 42°. On cooling the substance remained permanently fluid, though a fragment of either solid form caused crystallization at once. The author explains this isomerism on the hypothesis of Naumann, that physical molecules are aggregations of chemical molecules, and that the stable molecules are composed of a larger number of chemical molecules than the unstable. Hence the fusing points of the latter are lower, the specific gravity is less and the specific heat is greater. —*Ber. Berl. Chem. Ges.*, ix, 760, June, 1876. G. F. B.

6. *Synthesis of Allantoin.*—As pyruvic acid acting upon urea gives a homologue of allantoin, GRIMAUX acted upon urea with glyoxylic acid in expectation of obtaining allantoin itself. One part of glyoxylic acid was heated to 100° with two parts of urea for eight to ten hours. The mass was extracted with boiling alcohol, and the residue was dissolved in twelve to fifteen times its weight of hot water. On cooling beautiful crystals were deposited, which gave on analysis the formula $C_4H_6N_4O_3$, a glyoxylic diureide. Its identity with allantoin was completely proved by its chemical reactions, by its solubility, by its crystalline form, etc. The rational formula

$$\begin{array}{l} CH \begin{array}{l} \diagup NH-CO-NH_2 \\ \diagdown NH \diagdown \end{array} \\ | \qquad\qquad\qquad CO \\ CO-NH \diagup \end{array}$$

is assigned to it by the author.—*C. R.*, lxxxiii, 62, July, 1876. G. F. B.

7. *High Pressure Manometer.*—M. L. CAILLETET, in a recent examination of the change of volume which a cylindrical reservoir of glass undergoes, found this change exactly proportional to the pressure. Experiment carried to the point of fracture showed that this law held at even the highest pressure, and that moreover the glass underwent no permanent change in shape. An extremely simple manometer is based on this principle. It consists of a sort of glass thermometer whose cylindrical reservoir is enclosed in spherical cups and filled with colored liquid or mercury. The capillary tube is calibrated with care and is

enlarged at one point so that it may be attached to the reservoir by gutta percha passing through a copper orifice. The latter is then closed by a screw surrounding the tube. Liquid being pressed into the outer reservoir compresses the glass and causes the mercury to rise in the tube by an amount proportional to the pressure.

It is indispensible that the temperature of the apparatus should be constant, which is easily accomplished by surrounding it with water or melting ice. In rapid determinations even these precautions are needless. It is only necessary to take care before applying the pressure to see that the level of the liquid coincides with the zero of the graduated scale. If this is not the case the scale should be raised or lowered to the proper position. By varying the relative dimensions of the tube and reservoir any desired sensibility may be attained. A comparison of this instrument with the open-air manometer of the College of France shows that the liquid displaced by the diminution of the glass envelope rises to a height exactly proportional to the pressure exercised upon its walls. In fact this should be so, for if we take for abscissas the pressures and for ordinates the volumes of the peizometer, the compressibility of the glass being very small this volume changes but little, so that for very different pressures p and p', the volumes v and v' differ but little; consequently the curve, whatever it may be, will approach very nearly to a straight line. Consequently the change in volume of the reservoir ought to be proportional to the increase in pressure, and this within very wide limits, provided the change in volume is small.—*Journ. de Phys.*, v, 181. E. C. P.

8. *Waves on Lake Geneva.*—Dr. FOREL gave the London Physical Society an account of some interesting observations which he has recently made on the periodic waves which take place on the Swiss Lakes and are there called "Seiches." It has long been observed that the waters of most of these lakes are subject to a more or less regular rise and fall, which at times has been found to be as much as one or two meters. Dr. Forel has studied this phenomenon in nine different lakes, and finds that it varies with the length and depth of the lake and is in every way analogous to that already studied by Prof. Guthrie in artificial troughs, and follows the laws which he has deduced from his experiments. Most of the observations in Switzerland were made on the Lake of Geneva, but that of Neuchâtel was found to be best fitted for the study of the subject, possessing as it does an extremely regular geometric form. The apparatus he employed was very sensitive to the motion of the water, being capable of registering the waves caused by a steamboat half an hour after it had passed and five minutes before its arrival, and was so constructed as to eliminate the effect of common waves, and to register the motion side by side with a record of the state of the barometer, on paper kept in continuous motion. While he found the duration of waves to be ten minutes at Monges it was seventy

minutes at Geneva, and this is explained by the narrowness of the neck of the lake at the latter place. This period he proved to be independent of the amplitude, and to be least in the shortest lakes. For shallow lakes the period is lengthened, and his observations show that the period is a function of the length and depth and that longitudinal and transverse waves may coexist, just as Prof. Guthrie has shown to be the case in troughs.—*Nature*, xiv, 164. E. C. P.

9. *Friction of the Ether.*—Mr. W. M. HICKS drew the attention of the Cambridge Philosophical Society to some experiments of Messrs. Stewart and Tait on the heating of disks by rapid rotation in vacuo, and which they referred to the friction of the ether. He showed that it was not necessary to have recourse to this explanation, that nearly all the effects could be accounted for if it is supposed that the disc, through the rapid rotation, has expanded and consequently been lowered in temperature, that whilst rotating it is raised to the temperature of the surrounding region, and, therefore, when the rotation is stopped, and the disc has shrunk to its former size, it will give out the heat it had taken in whilst rotating. In the case of silver it was shown that the disc ought to show a rise of ·4°C., if the rotation had been continued for some time, and this was compared with the rise of ·47°C. which Messrs. Stewart and Tait had observed in an aluminum disc, thus showing that the effect was of the same order of magnitude in the two cases. It was also shown that if the whole heating were due to ethereal friction, that this friction would be ·0006 lbs. per square foot, and that if we suppose this amount to act on the surface of the earth, the day would be lengthened in the course of a century by something like ·006″.—*Nature*, xiv, 144. E. C. P.

10. *Specific heat of Gases.*—M. M. KUNDT and WARBURG have determined experimentally the ratio of the two specific heats of mercury vapor which has been supposed by chemists to consist of monatomic molecules. According to the Kinetic theory of gases, supposing the gaseous molecule to consist of only one atom, the relation of the two specific heats (as Clausius has shown) would be 1·666. The lower number obtained by experiment for several gases may probably be explained by the complete constitution of their molecules. The method here employed was to produce a sound in two glass tubes placed end to end, and containing, one mercury vapor, the other air. Having introduced powder into the tubes they observed the distances between the nodes of vibration. Applying the formula for the velocity of sound which includes the densities, temperatures, and the ratio of the specific heats, and taking as the value of this ratio in the case of air, the number 1·405, they obtain, for mercury vapor the number 1·67, which may be considered as fully in accord with the number 1·666 furnished by theory.—*Pogg. Ann.*, iii, 1876. *Nature*, xiv, 182. E. C. P.

II. Geology and Mineralogy.

1. *Geological Survey of Canada;* Alfred R. C. Selwyn, F.R.S., Director. *Report of Progress* for 1874–75. Montreal. 320 pp. 8vo. 1876.—This report consists of an introductory report by Mr. Selwyn; reports on the country west of Lake Manitoba and Winnepegosis, and on the geology of Lake Winnipeg, by Mr. R. Bell; on the country between the Upper Assineboine River and Lakes Winnepegosis and Manitoba, by Mr. J. W. Spencer; on explorations in British Columbia, by Mr. J. Richardson; on observations in New Brunswick, by Prof. Bailey and Mr. Matthew; on boring operations in New Brunswick, and on the iron ore deposits of Carlton Co., N. B., by Mr. R. W. Ells; on portions of Frontenac and Lanark Counties, and on the economic minerals, by Mr. H. G. Vennor; on explorations in Cape Breton, by Mr. C. Robb; on statistics of the trade and manufacture of Canadian salt, by Mr. J. L. Smith; on some Canadian minerals, by Mr. B. J. Harrington; chemical contributions, by C. H. Hoffmann. The reports contain much of value to science. We cite a few of the facts:

Glacial Striæ.—According to Mr Bell the glacial striæ on the east side of Lake Winnepeg, and between Lake Winnipeg and Lake Superior, run generally to the southwestward. This direction confirms the view, presented by the writer, that the great glacier had its maximum height above the sea-level between that region and the Atlantic coast along the area of greatest precipitation, and that it thinned down toward the continental interior.

Heights of Lake Winnipeg and others.—Mr. Bell states that the Canadian Pacific Railway Survey obtained, by a series of spirit levels carried all the way from the sea, for the height above sea-level of Lake Winnipeg, 710 feet; St. Martin's Lake, 737 feet; Lake Manitoba, 752 feet; Lakes Winnipegosis and Cedar, 770 feet; Lake of the Woods, 1,042 feet.

Mascarene Series of New Brunswick, Upper Silurian in age.—Messrs. Baily and Matthew in their report state that the so-called "Mascarene series" of Southern New Brunswick, containing diorytes, felsytes, argillytes, is of Upper Silurian age. It includes below, sandstones, and red, green, and purplish argillytes, affording on the southwest side of Passamaquoddy Bay numerous shells of the genera *Modiolopsis*, *Lingula*, and *Loxonema*; and above, diorytes, felsytes (the color usually brick red) and red slates. On the Mascarene shore the rocks have a thickness of about 2000 feet. The lowest division, consisting of about 400 feet of feldspathic slates, affords Upper Silurian fossils at Back Bay of La Tete Harbor, at Frye's Island and at Oak Bay. The next division, about 600 feet thick, is stated to afford remains of "*Cordaites*, a large *Cyclopteris*, probably a *Sphenopteris*, and a *Carpolite*, and striate and punctate stems of Ferns."

Analyses and Descriptions of Minerals.—Mr. Harrington gives

analyses of an aluminous pyroxene from Grenville; sodalite and natrolite, from felsytic dikes, intersecting Trenton limestones near Montreal; Chromiferous serpentine from Bolton or Melbourne; pyrrhotite of Elizabethtown; serpentine containing magnesite; feldspar of a dioryte, near anorthite; and Mr. Hoffmann, analyses of kaolinite; a Hisingerite-like mineral from Elizabethtown; a feldspar (labradorite) of a dioryte from North Sherbrooke; and a pyrite from Londonderry, Nova Scotia, besides analyses also of some mineral waters. J. D. D.

2. *Bulletin of the Geological and Geographical Survey of the Territories*, Dr. F. V. HAYDEN in charge. Vol. ii, No. 4, pp. 279–374 (closing the volume). Washington, August 4, 1876. Department of the Interior.—This new number of the Bulletin contains the following papers: Notes on the Geology of Northeastern New Mexico, by O. ST. JOHN; on Sexual, Individual and Geographical variation in *Leucosticte Tephrocotis*, and on geographical variation among North American Mammals, especially in respect to size, by J. A. ALLEN; on fossils from Vancouver's and Sucia Islands, and other northwestern localities, and on the New Genus, *Uintacrinus* of Grinnell, by F. B. MEEK. Mr. St. John treats of the Cretaceous and Tertiary strata of the region, the mesas of basalt, besides the general features of the valleys, parks and ridges, and illustrates his subject by admirable sketchy views, illustrating both the geology and scenery. He states that "the basin of the Canadian is partially surrounded on two sides by the immense basaltic-capped mesas, the flat summits of which rise 1,000 to 1,500 feet above its surface." The plain itself is everywhere traversed by dikes, the rocks of which are the same as those of the mesas. The Capulin country to the east of the Canadian has similar mesas of varying height; and all were once probably united. The basaltic layers usually overlie directly Cretaceous or Tertiary beds, and were ejected at the close of the Tertiary.

Mr. Allen shows that the individuals of the species of *Felidæ* of North America increase in size to the southward; of the *Canidæ* and *Procyonidæ* increase to the northward and decrease to the southward; of the *Ursidæ*, increase to the northward; of the *Sciuridæ*, and *Leporidæ* also increase to the northward or decrease to the southward; and he states the general conclusion—that the individuals are largest in the region "where the group reaches its highest development, or where it has what may be termed its center of distribution;" and "the most typical or most generalized representatives of a group are found near its center of distribution, outlying forms being generally more or less "aberrant" or "specialized." See for a further notice of Mr. Allen's memoir, by Prof. Verrill, page 238 of this volume.

Mr. Meek describes three Carboniferous species from the borders of Washington Territory near 49° north and 114° west, and several Cretaceous species from Vancouver's and the Sucia Islands. The paper is illustrated by six plates. Mr. Meek also describes

and figures specimens of the *Uintacrinus socialis* of Grinnell—a Cretaceous Crinoid,—and points out some characters that were not distinct in Grinnell's specimens.

3. *Report of the Exploring Expedition from Sante Fé, New Mexico, to the junction of the Grand and Green Rivers of the Great Colorado of the West*, in 1859, under the Commander, Capt. (now Colonel) J. N. MACOMB, Corps Topogr. Engineers; with the *Geological Report* of Prof. J. S. NEWBERRY, Geologist of the Expedition. Engineers' Department, U. S. Army. 148 pp. 4to.—This volume, excepting the first four pages occupied with the General Report of Colonel Macomb, is made up of the Geological Report of Prof. Newberry, a Paleontological report on the Carboniferous and Triassic fossils, by the same author, and another on the Cretaceous Fossils, by Mr. F. B. Meek. The text is illustrated by a number of excellent lithographs printed in colors, representing geological views, and the paleontological descriptions by eight plates of fossils.

The expedition was in the field during the summer of 1859; and the report of Dr. Newberry, its geologist, bears the date "May 1, 1860;" but the "breaking out of the rebellion" arrested its publication, and only recently was its printing ordered.

Dr. Newberry remarks that the region has since been the field of several exploring and surveying expeditions, and the subjects of their reports; so that the results he obtained have been partly anticipated. He has wisely, however, published his report as it was written, without reference to the later works. The report is therefore all the more valuable as independent testimony with regard to the geological structure of the country. It treats of the coal and the Coal-measures of Kansas, and the extension of the Carboniferous (Coal-measure) limestone westward; of the succeeding Permian, first met at Dragoon Creek; of the Gypsum formation (Triassic or Triassic and Jurassic) which overlies the Permian from the west side of Cottonwood Creek to Walnut Creek; of the Lower Cretaceous beds of Walnut Creek to Pawnee Fork; of the "Tertiary basin of the Arkansas," as Dr. Newberry had before designated it, whose western margin crosses the Santa Fé road west of the Pawnee Fork; and of the Tertiary, Cretaceous and other strata on the way to Santa Fé; of the Geology of the vicinity of Santa Fé; of the Geology of the route from Santa Fé to the Sierra la Plata, including a description of the boiling spring of Pagosa, 40 to 50 feet in diameter, in apparent ebullition from escaping gases, situated on the San Juan, up the valley between the Sierra San Juan and the Sierra del Navajo; on the Geology of the Sage-Plain and Valley of the Upper Colorado, with an account of the cliff habitations; and on the region of the San Juan. Dr. Newberry describes and figures Triassic plants (*Otozamites*, *Zamites*, *Pecopteris*, *Pterophyllum*, *Podozamites*, *Alethopteris*, *Camptopteris*, *Tæniopteris*, and *Jeanpaulia*) from Los Bronces or Yaki River, Sonora, and from the copper mines near Abiquiu, New Mexico, besides some Carboniferous and Cretaceous fossils;

and Mr. Meek, various Cretaceous species. Dr. Newberry mentions that a larger species of Jeanpaulia has been observed by him among the plants of the Triassic of North Carolina.

It is greatly to be regretted that the publication of this excellent volume has been so long delayed.

4. *Report of Explorations across the Great Basin of the Territory of Utah, for a direct wagon-route from Camp Floyd to Genoa in Carson Valley*, in 1859, by Capt. (now Colonel) J. H. SIMPSON, Corps Topogr. Engineer, U. S. A. Engineers' Department, U. S. A. 494 pp. 4to, with plates and maps. Washington, 1876. Containing a Geological Report of Mr. HENRY ENGELMANN; Paleontological, of Mr. F. B. MEEK; Ichthyological, of Mr. T. GILL, etc.—The explorations here recorded were made in 1859, and the report now published bears the date Febuary 5, 1861—the delay in publication having been occasioned by the civil war.

The volume is occupied chiefly by the observations of the Engineer corps—including, the results of astronomical, topographical, climatal, magnetic and other related investigations, tables of distances, altitudes and grades of routes; but contains also a history of the explorations of the Great Basin from the time of Father Escalante in 1776 to the present period, and a general description of the country, with Captain Simpson's Itineraries; also a Geological Report, occupying 92 pages, by Henry Engelmann, geologist of the expedition, a Paleontological Report, of 40 pages, by Mr. F. B. Meek; and Appendixes on the Birds, by Prof. Baird, on the Fishes, by Mr. T. Gill, on the Botany, by Mr. G. Engelmann, and on Eastern Utah and its Indians, by Dr. G. Hurt. The delay in the publication of Mr. Henry Engelmann's valuable report has lost him the credit of first discovery in many points connected with the geology of the region. It treats of the geology of Eastern Kansas and Southeastern Nebraska; of the plains next west, to the foot of the Rocky Mountains; of the district of the Rocky Mountains, between Fort Laramie and the South Pass; of the Green River Basin, and the region west to the axis of the Wahsatch Mts.; the district of Central and Western Utah, the so-called Great Basin. Mr. Meek's report gives descriptions and figures of Devonian, Carboniferous, Jurassic, Cretaceous and Tertiary fossils, the illustrations occupying five plates. The Ichthyological Report of Mr. Gill is accompanied by eleven lithographic plates, and the Botanical Report of Mr. G. Engelmann, by three plates, illustrating the species *Echinocactus Simpsoni* Engelm. and *Opuntia pulchella* Engelm.

5. *Fossil marine plants from the Coal-measures.*—Mr. LESQUEREUX, in the Report of the Indiana Geological Survey for 1875, has described three species of sea-weeds of the Lower Silurian genus *Palæophycus* Hall, from iron concretions in a bed of clay over coal L, on a branch of Salt Creek, Vigo County, Indiana; also others of the new genera *Asterophycus* from a sandstone connected with coal-beds near New Harmony, Indiana, and from the Lower Carboniferous, Rock Castle, Kentucky, and *Conostichus*, from Port Byron, Illinois and from Indiana.

6. *Remarks on Fossils from the Ashley Phosphate Beds.*—Prof. LEIDY observed that the so-called phosphate beds of Ashley River, South Carolina, were remarkable for the singular admixture of multitudes of fossils of different ages, from the early Tertiary period inclusive down to the present epoch. The phosphatic nodules, for which the beds are explored, appear to have had their origin from the Eocene rocks beneath. These have also contributed numerous remains of marine vertebrates, especially of squalodonts, reptiles, and fishes. Mingled in the sand and clay with the phosphatic nodules and bones of Eocene animals, are innumerable remains of cetaceans, sharks, and other marine animals of perhaps the middle and later Tertiary ages. Added to these are multitudes of remains of both marine and terrestrial animals of the Quaternary period. There are found pell-mell together bones of Eocene squalodonts, animals related to the whales and seals; hosts of teeth of the great shark *Carcharodon augustidens;* myriads of teeth of the giant of sharks of the Tertiary period, the *Carcharodon megalodon;* bones and teeth of whales and porpoises; and abundance of remains of elephant, mastodon, megatherium, horse, etc.; and occasionally the rude implements of our more immediate ancestors.

From among a collection of fossils from the Ashley phosphate beds, recently submitted to his inspection by Mr. J. M. Gliddon, of the Pacific Guano Company, the specimens were selected which lie upon the table. One of these is a well-preserved tooth of a Megatherium; another, a characteristic portion of the skull of a Manatee; a third, a complete tusk of the Walrus; indicating a still farther point south for the extension of this animal than had been previously known; fourth, a huge tooth of a cetacean allied to the sperm whale, probably the same as those from the crag of Antwerp ascribed to Dinoziphius. Besides these there are the beaks of three cetaceans of the little known family of the Ziphioids. These are porpoise-like animals, without teeth in the upper jaw, and usually with but a single pair of teeth in the lower jaw. The beaks, composed of the co-ossified bones of the face, are remarkable for their ivory-like density which probably rendered them available as weapons of defence.

A fourth beak from the same locality, presented by Mr. C. S. Bement, belongs to a different species of the same family. The beaks and some associated fossils will form the subjects of a paper shortly to be presented to the Academy.

The beaks have been referred to species with the following names and brief distinctive characters:—

Choneziphius trachops.—Supra-vomerian canal open. Intermaxillaries co-ossified and forming a crest along the middle of the beak extending to the interval of the prenareal fossæ. Maxillaries with a rugged tract at the upper part of the base of the beak.

Choneziphius liops.—Beak proportionately of less length than in the preceding. Supra-vomerian canal and intermaxillaries the

same, except that the crest of the latter in front is acute. Maxillaries without the rugged tract at base.

Eboroziphius cœlops.—A new genus as well as species. Beak above forming a broad gutter as in Hyperoodon, and not divided by an intermaxillary crest as in the preceding. Maxillaries with prominent lateral crests at base, convex inwardly. Right prenareal fossa occupied by a thick osseous disk. Intermaxillaries coössified. Supra-vomerian canal open.

Belemnoziphius prorops.—Beak solid, with all traces of the original separation of the constituent bones and the ossified mesethmoid cartilage obliterated.—*Proc. Acad. Nat. Sci., Philad.*, May 9.

7. *Fish Remains of the Mesozoic Red Shales.*—Prof. LEIDY remarked that the remains of life were rare in the Mesozoic red shales which cross Pennsylvania about fifteen miles north of Philadelphia. Hence any fossils whatever from these rocks were of interest. The three cycloid fish scales, and a few detached caudal rays, in the fragments of red shales, presented by him this evening, he found on the Perkiomen Railroad, near Yerkes' Station, Montgomery County. One of the scales resembles those described by the late Prof. E. Emmons, under the name of *Rhabdiolepis elegans*, from the mesozoic coal shales of Chatham Co., N. C.—*Proc. Acad. Nat. Sci., Philad.*, May 9.

8. *A Study of the Rhætic Strata of the Val di Ledro, in the Southern Tyrol;* by T. NELSON DALE, JR., Mem. Geol. Soc. de France. 70 pp. 8vo, with maps and sections. Paterson, N. J. 1876.—The author gives the results of his geological explorations in the Southern Tyrol, and illustrates his subject with a colored geological map and many sections.

9. *On the Mammalia and Traces of Man found in the Robin-Hood Cave;* by W. BOYD DAWKINS.—The author noticed the various species of animals discovered by Mr. Mello during the researches, the results of which are given in another paper, and drew certain conclusions from their mode of occurrence as to the history of Robin Hood's Cave. He considered that the cave was occupied by Hyænas during the formation of the lowest and middle deposits, and that the great majority of the other animals whose remains occur in the cave were dragged into it by the Hyænas. That they served as food for the latter is shown by the condition of many of the bones. During this period the red sand and clay of the lowest stratum was deposited by occasional floods. The red loam or cave-earth forming the middle stratum was probably introduced during heavy rains. The occupation of the cave by Hyænas still continued, but it was disturbed by the visits of Palæolithic hunters. The remains found in the breccia indicate that the cave was inhabited by man, and less frequently visited by hyænas than before. The presence of vertebræ of the hare in the breccia would imply that the hunters who occupied the cave had not the dog as a domestic animal. After a discussion of the relations of the animals forming the fauna of the cave, the author

proceeded to describe the traces of man found in it, which consist of fragments of charcoal, and implements made of antler and mammoth-tooth, quartzite, ironstone, greenstone and flint. The distribution of these implements in the cave represents three distinct stages. In the cave-earth the existence of man is indicated by the quartzite implements, which are far ruder than those generally formed of the more easily fashioned flint. Out of 94 worked quartzite pebbles only three occurred in the breccia, while of 267 worked flints only eight were met with in the cave-earth. The ruder implements were thus evidently the older, corresponding in general form with those assigned by De Mortillet to "the age of Moustier and St. Acheul," represented in England by the ruder implements of the lower breccia in Kent's Hole. The newer or flint series includes some highly finished implements, such as are referred by De Mortillet to "the age of Solutré," and are found in England in the cave-earth of Kent's Hole and Wookey Hole. The discovery of these implements considerably extends the range of the Palæolithic hunters to the north and west, and at the same time establishes a direct relation in point of time between the ruder types of implements below and those more highly finished above.—*Proc. Geol. Soc., in Ann. Mag. Nat. Hist.*, Aug., 1876.

10. *Evidences of Theriodonts in Permian Deposits elsewhere than in South Africa;* by Prof. R. Owen.—In this paper the author noticed some described Reptilia which he believes to belong to his order *Theriodontia.* In 1838 Kutorga described as probably mammalian the distal end of a humerus showing a perforation or canal above the inner condyle. The specimen was from the Permian of the Western Ural; and Kutorga gave it the name of *Brithopus priscus.* Under the name of *Orthopus primævus* he described the proximal part of the humerus of the same species, perhaps of the same bone. There is thus evidence of an extinct reptile in the Permian deposits of the Ural with a humerus showing the characters of the Theriodont reptiles of the Karoo series of South Africa. The British Museum possesses a cast of the first-mentioned fragment, labelled by Krantz "*Eurosaurus Uralensis*, H. von Meyer, *Brithopus priscus*, Kutorga." The genus *Eurosaurus* was founded in 1842, by Fischer von Waldheim, upon some fragments of bone, including a humerus with a broad proximal end as in Kutorga's *Orthopus;* and Fischer also noticed a humerus showing characters like those of Kutorga's *Brithopus*, from the same locality as the portion of a jaw described under the name of *Rhopalodon Wangenheimii* Fischer, which contained nine molar teeth, with thick, pointed, subcompressed crowns, with trenchant and serrate borders. In 1858 H. von Meyer described a skull from the Permian of the Ural, under the name of *Mecosaurus Uraliensis*, as a Labyrinthodont; and Eichwald referred this genus, with Kutorga's *Brithopus* and *Orthopus*, to Fischer's *Eurosaurus.* The author regarded *Mecosaurus* as truly Labyrinthodont; whilst the Permian forms constituting Kutorga's genus he referred to the Theriodont order. From

the same locality as the above, Kutorga describes *Syodon biarmicum* as probably a Pachyderm. Its teeth resemble those of *Cynodraco.* Eichwald's *Deuterosaurus biarmicus* is founded upon the fore part of both upper and lower jaws of a reptile, containing teeth with denticulate or crenulate trenchant borders, the canines being large, especially in the upper jaw. *Deuterosaurus* closely resembles *Cynodraco*, and still more the *Lycosaurus* of the Karoo beds of the Sneewberg range. All the above are from the Permian beds of the Ural; and the author regards them as furnishing suggestive evidence of the Palæozoic age of the Karoo series, in which the Theriodont reptiles are best represented.

The author further notices a Theriodont allied to *Lycosaurus*, from a red sandstone, probably of Permian [Triassic?] age, in Prince-Edward Island. The remains include the left maxillary, premaxillary, and nasal bones; the teeth, implanted in distinct sockets, have subcompressed, recurved, conical, pointed crowns, with minutely crenulated borders. The foremost tooth in the maxillary is a canine; and in other points the dentition shows Theriodont characters This fossil has been described by Dr. Leidy under the name of *Bathygnathus borealis.* Thus, supposing the affinities of the fossils from the Ural and Prince-Edward Island to be correctly determined, the Reptilia distinguished by Mammalian characters are shown to have had a very wide range. Further, the author thinks that the Theriodont reptiles of the Bristol dolomitic conglomerate may also prove to constitute a family in the Theriodont order.—*Proc. Geol. Soc., in Ann. Mag. Nat. Hist.*, Aug., 1876.

11. *Silurian dioryte, chlorite slate and serpentine in Newfoundland.*—Mr. Howley's labors in Newfoundland during 1874 were, in accordance with Mr. Murray's plans, given to the survey, topographical and geological, of the western coast, about the peninsula and bay of Port-a-Port, and St. George's Bay. In tracing the Lower Silurian formations of the Newfoundland coast, Mr. Murray and his colleagues have been able to identify them with more or less precision as equivalents of the Quebec and Birdseye and Black River groups of Canada. But in the course of their surveys they have at different times encountered intercalated sheets of metamorphic rocks in the Lower Silurian series, overlying unaltered and fossiliferous strata. Thus, at Bonne Bay, in 1862, Mr. Richardson found highly metamorphosed rocks, including white talcose slates and serpentine, in some portion apparently of the Quebec group. Four years afterward Mr. Murray observed, farther south, in the Bay of Islands, that sandstones believed to represent the Sillery zone of the Quebec group passed below the serpentine of the Blowmedown Mountains. Mr. Howley has now confirmed and extended these observations by mapping the country between the Bay of Islands and St. George's Bay. He has traced Mr. Murray's serpentine rocks southward to Bluff Head, and finds that they pass unconformably over different horizons of rocks which are taken to represent the Sillery and Levis subdivisions of the Quebec group of the Lower Silurian system. The

striking character of this unconformable junction is well brought out upon the map, where two large cakes of the overlying rocks are seen to sweep over both anticlinal and synclinal folds of the lower formations. These cakes consist of brecciated dolomite or limestone, chlorite-slate, dioryte and serpentine, having a total thickness of perhaps 1,500 feet. Their exact geological horizon seems not yet quite satisfactorily fixed, but they are placed provisionally between the Sillery and Birdseye and Black River formations. Doubtless further details will be given in future reports regarding this remarkable feature of Newfoundland geology, and till they appear, it may be well to avoid any discussion of the theoretical aspect of the subject. It is not the first time that an instance has occurred of the higher rocks of a district being more metamorphosed than the lower, but there has probably never been observed so remarkable a case, for here the metamorphosed and contorted series is described as actually overlying unmetamorphosed strata.—*Notice of the Report on the Geological Survey of Newfoundland for* 1874, *in Nature of July* 20.

12. *Oldhamia in Wisconsin.*—In a letter to one of the editors of this Journal from Mr. J. W. Porter, dated Eau Claire, Wisconsin, June 12th, the writer states that he has found the *Oldhamia radiata* abundantly and very perfect in the vicinity of Eau Claire. In the bluff around this place there is a large exposure of Potsdam sandstone, quite fossiliferous, with numerous Trilobite impressions of several species, Pteropods and Lingulæ, besides Fucoidal impressions and wave marks. With the *Oldhamia radiata* occurs *Scolithus linearis*, and neither of them seems to extend as high as to the beginning of the other forms, or to the bottom of the sandstone exposures.

13. *Reef-building corals in the Tasmanian Tertiary.*—Professor P. Martin Duncan has described the new reef-building species *Heliastræa Tasmaniensis*, *Thamnastræa sera* and another species of Thamnastræa, from Cape Howe, Tasmania, 15° of latitude south of the present southern limit of the coral-reef seas in that part of the ocean.

14. *Carboniferous Pulmonates.* (From a letter to the editors, dated Montreal, July 24, 1876.)—In a recent visit to the South Joggins, in which I was assisted by Albert I. Hill, Jr., of the Cumberland Coal Mine, we succeeded in tracing *Pupa vetusta* to a higher level in the Coal formation than previously. A number of specimens were found in the material filling an erect Sigillaria in group XXVI of my section of the South Joggins, the same group in which Marsh's *Eosaurus* was found, and which has also afforded reptilian footprints. The bed is 222 feet above the main coal seam, 842 feet above the bed in which this shell was first discovered by Sir C. Lyell and myself, and about 2,000 feet above the lowest bed in which I have as yet found specimens. It thus appears that this little pulmonate continued to flourish in the Carboniferous swamps after its ancestors had been buried by 2,000 feet of sediment, including many beds of coal and nearly the

whole thickness of the productive Coal-measures. Its companion pulmonate, *Conulus priscus*, has as yet been found only in the lowest of the beds above referred to.

We were so fortunate as to discover, on the same expedition, another large Sigillaria stump, stored with reptilian bones; which it is hoped may afford some interesting additions to the land fauna of the Coal period. J. W. DAWSON.

15. *Brachiopods of the Swedish Paradoxides beds of Sweden.*—M. Linnarsson enumerates and describes the following Swedish Brachiopods (Swedish Acad. Sci., May 12, 1875): *Orthis Lindströmi* Linnarsson, *O. exporrecta* Linn., *O. Hicksi* Salt., *Lingulella* (?) *Nathorsti*, *Obolus* ——? *Acrotreta socialis* v. Seebach, *Obolella sagittalis* Salt., *Acrothele* (n. g.) *coriacea* Linn., *A. granulata*, *Kutorgina cingulata* Bill. var. *pusilla*, *Iphidea ornatella* Linn.

The Paradoxides and lower beds of Great Britain have thus far afforded only *Lingulella ferruginea* Salt., *L. primæva* Hicks, *Discina pileolus* Hicks, *Obolella sagittalis* Salt., *O. maculata* Hicks, *Orthis Hicksi* Salt., with perhaps *Kutorgina cingulata* Bill.

Including all *known* species, the number of species is small compared with that of the trilobites, the ratio being 29 to 150 of the latter. In general the Paradoxides beds are characterized by the most of their Brachiopoda having a corneous shell. The generic types *Kutorgina*, *Acrothele* and *Iphidea* have not been found in later beds.

16. *Geological Survey of Brazil.*—A recent letter to Prof. T. B. Comstock from Prof C. F. Hartt, head of the Geological Survey of Brazil, states that he is preparing to send one division of his corps, probably under the direction of Mr. O. A. Derby, to make a careful examination of the Amazonian Country, and to connect the explorations of this region with those now in progress to the southward, in the interior of Brazil, and along the coast.

17. *Geological Map of Illinois.*—The geological map of Illinois, announced as nearly ready by Mr. Worthen in the last (sixth) volume of his Geological Report, has been published. It is of large size and well colored.

18. *Report on the Chemical, Mineralogical and Microscopical Characters of the Lavas of Vesuvius, from* 1631 *to* 1868; by Rev. SAMUEL HAUGHTON, of Trinity College, Dublin, and EDWARD HULL, Director of the Geological Survey of Ireland. 164 pp. 4to. 1876. Art. III of vol. xxvi, of Trans. R. Irish Acad., Dublin.—In this elaborate memoir the chemical and mineralogical part is by Dr. Haughton, aided in the chemical analyses by Mr. Wm. Early, and the microscopical, by Mr. Hull. The minerals found by the latter to be present in all the lavas, are leucite, anorthite, augite, magnetite and nephelite; in many of them, traces of sodalite, olivine, hornblende and mica; in several, sanidine, but this is rarely a prominent constituent; in a few, a little apatite. In the discussion of the chemical results with reference to the proportions of these mineral constituents, Dr. Haughton, by a simple

mathematical method, obtains the maximum and minimum of the amount possible for each constituent. The probable proportions of some of the constituents are then deduced from their relations in composition, and a mean possible value obtained for the rest. A comparison of the chemical composition of these minerals with the chemical composition of the lava, gives by subtraction, the chemical composition of the paste. The amount of paste is arrived at through the assumption that "*of the numerous possible solutions, that will be the occurring one in Nature which involves the largest amount of definite minerals and the least amount of indefinite paste.* Calculating from this basis, he arrives at the compositions of twenty Vesuvian lavas ejected at different times from 1631 to 1868, of which the following are examples:

	Gravina. 1631.	Granatello. 1631.	Della Scala. 1631.	C. de S. Vito. 1767.	C. de Salvatore. 1834.	The Atrio. 1855.	T.d.Greco. 1861.
Leucite,	38·2	33·6	40·6	41·4	39·7	36.8	34·2
Anorthite,	6·6	0·6	6·9	9·4	0·4	11·8	11·6
Magnetite,	7·14	4·45	4·9	6·9	9·7	3·35	3·74
Olivine,	tr.	tr.	tr.	tr.	tr.	tr.	....
Augite,	28·6	41·2	31·1	25·1	27·4	28·7	30·4
Hornblende,	tr.	tr.	....	....	tr.	tr.	....
Mica,	tr.	....	....	....	....	....	....
Nephelite,	10·5	10·0	6·5	8·6	11·2	11·5	10·9
Sodalite,	tr.	tr.	tr.	....	....	tr.	tr.
Apatite,	....	0.44	1·1	....	....	tr.	San.
Paste,	8·96	9·71	8·9	8·6	11·2	9·6	9·16
	100·00	100·00	100·0	100·0	100·0	100·0	100 00

The ingredients of the paste, as deduced by the method adopted, are silica, lime and protoxide of iron, and the mean composition, according to Dr. Haughton, corresponds to the formula 2RO, SiO_2, "which represents a very fusible basic glass, of a brownish color from the large quantity of iron protoxide." The order of formation of the minerals, according to Dr. Haughton's views, is first the potash and soda minerals, leucite and nephelite or sodalite; then the magnesia mineral, augite; and lastly magnetite and anorthite.

The analysis of the Vesuvian augite which is taken for the calculations is that of Wedding, of augite from a lava of 1631, giving only 4·54 p. c. of protoxide of iron; the analysis of Rammelsberg, of the augite from a Vesuvian lava of 1858, gave 9·08 FeO. The constituent augite—one of the four always present—is hence one source of uncertainty in such calculations, for the maximum deduced (the amount usually taken by Dr. Haughton in his final results) will differ widely in the two cases. Further, the CaO not used by augite belongs to anorthite, and therefore the proportion of anorthite would also be different. There is, hence, reason to suspect that the calculated percentage of anorthite in several of the tabulated results is below the actual amount present in the lavas.

19. *On the crystallographic relations of the three types of Chondrodite (Humite).*—M. DesCloizeaux in a recent letter, dated Paris, July 1st, 1876, gives the results of his researches in regard to the optical characters of chondrodite. These results are of especial interest as proving for the Swedish chondrodite, and the Vesuvian humite what has been shown by the writer to be true of the chondrodite from Brewster, N. Y.,—that the second and third types are monoclinic, not orthorhombic.

The principle conclusions of M. DesCloizeaux are, as follows.

The three types of humite, described by Scacchi, constitute three different species, closely related to each other in regard to form. The crystallographical and optical characters of the types are the following: Type I, humite from Vesuvius. Orthorhombic. Fundamental angles, as measured, *$A \wedge e^5 (pe^{\frac{1}{2}} = 001 \wedge 201) = 103^\circ\ 47'$, $A \wedge i^2 (pa^3 = 001 \wedge 013) = 124^\circ\ 16'$. The plane r^5 is made the fundamental pyramid with $A \wedge r^5 (pb^{\frac{1}{2}} = 001 \wedge 111) = 101^\circ\ 39'$, and o^2 is made the unit prism, $B \wedge o^2 (100 \wedge 110) = 114^\circ\ 50'$. Plane of the optic axes parallel to the base, with the acute bisectrix parallel to the shorter diagonal of the base. Dispersion weak, perhaps $\rho < v$; $2H\alpha$ (red rays) $= 78^\circ\ 18' - 79^\circ$.

Type II, chondrodite from Sweden. Monoclinic. Fundamental angles $A \wedge e^2 (ph = 001 \wedge 100) = 108^\circ\ 58'$; $A \wedge i (pe^1 = 001 \wedge 011) = 122^\circ\ 29'$; $C \wedge n^{2\prime} (g^1 h^3 = 010 \wedge 210) = 135^\circ\ 41'$. The planes r^2 and r^3 are made the unit pyramids; $A \wedge r^2 (pd^{\frac{1}{2}} = 001 \wedge 111) = 125^\circ\ 50'$, and $A \wedge r^3 (pb^{\frac{1}{2}} = 001 \wedge \bar{1}11) = 113^\circ\ 28'$. Plane of the optic axes inclined to the front edge, and making an angle of about 30° with the base. The crystals, mostly twins, composed of hemitropic bands parallel to the base; two collections of these bands were observed in one crystal united by an irregular line not referable to any plane on the crystal. The number of these twinning bands varies with every specimen examined. Apparent axial angle (in oil), red rays, $86^\circ\ 27'$, blue, $86^\circ\ 38'$. Bisectrix positive, normal to the plane of symmetry. Dispersion also *crossed* (tournante). In several other crystals the axial angle was found to vary from $86^\circ\ 14'$ to $87^\circ\ 20'$.

Type III. Humite, color pale yellow, from Mt. Somma. Monoclinic. Fundamental angles; $A \wedge e^4 (ph' = 001 \wedge 100) = 100^\circ\ 48'$; $A \wedge i^2 (pe^1 = 001 \wedge 011 = 125^\circ\ 13')$; $C \wedge r^8 (g^1 m = 010 \wedge 110) = 154^\circ\ 48'$. The planes r^4 and r^5 are taken as the unit pyramids: $A \wedge r^4$ $(pd^{\frac{1}{2}} = 001 \wedge 111) = 125^\circ\ 47'$, $A \wedge r^5 = 001 \wedge \bar{1}11) = 119^\circ\ 17'$. Plane of the optic axes inclined to the front edge and making an angle of about 11° with the base. Dispersion of the axes feeble $\rho < v$. Dispersion also crossed, scarcely appreciable. Bisectrix positive, normal to the plane of symmetry. Axial angle (in oil), red rays, $84^\circ\ 38' - 85^\circ\ 4'$. The white crystals, which are in appearance

* The letters given are those of Scacchi, the symbols which follow are those of DesCloizeaux, in his own and in Miller's method of notation.

simple, are mostly complex, being composed of parallel hemitropic bands. A yellow crystal, on the other hand, cut parallel to the plane of symmetry, showed a method of twinning analogous to that observed by Scacchi; it was composed of *five* individuals.

M. DesCloizeaux has also made an important observation tending to explain the well known variation in the composition of the three types. A small crystal, apparently of the first type, sliced, and examined optically, showed that it was penetrated irregularly by a crystal of the third type. M. Des Cloizeaux concludes from this that the former analyses cannot be considered reliable, and that the true composition can be obtained only from crystals which have previously been subjected to an optical examination. The second type seems to be the most homogeneous, and the one whose composition has been most certainly determined.

For the sake of comparison the results obtained by the writer from an optical examination of the chondrodite from Brewster, N. Y. (this Jour., III, x, 89, Aug., 1875, and xi, 201, Feb., 1876) are here cited. It will be seen that those since obtained by Des Cloizeaux for the chondrodite of Sweden and humite of Vesuvius. agree very closely with them.

Type II, monoclinic; angle made by plane of optic axes with the base 25° 50′ (about 30°, DesCloizeaux). Bisectrix positive, normal to the plane of symmetry, $2H\alpha$ (red rays) $=88° 48'$ (86° 14′ -87° 20′, DesCloizeax).

Type III, monoclinic; angle made by the plane of the optic axes with the base about 7½° (11° DesCloizeaux, humite).

The measured angles upon the Brewster crystals, as was stated, were inconclusive except as proving that the obliquity did not exceed a very few minutes. How small the variation from the rectangular form is for crystals of the second type, as given by DesCloizeaux, may be judged from the following pairs of angles: $A \wedge e^2 = 109° 5'$, $A \wedge e^{2\prime} = 108° 58$; $A \wedge r^3 = 113° 28'$, $A \wedge r^{3\prime} = 113° 25'$, etc.; if the crystals were orthorhombic, as has been assumed, the planes e^2 and $e^{2\prime}$ would be identical, and the angles on the base A would be the same; so also for r^3 and $r^{3\prime}$. In the third type DesCloizeaux makes the monoclinic variation from the rectangular form about *two* minutes. Some additional crystals of the second type of chondrodite recently obtained from Brewster, N. Y., offer an opportunity to test by accurate measurement the amount of the obliquity for the species, which the writer will not fail to avail himself of at an early date. E. S. DANA.

20. *Die Mineralien Badens nach ihrem Vorkommen*, von GUSTAV LEONHARD. 3d ed. 65 pp. 8vo. Stuttgart, 1876.—The Grand Duchy of Baden is remarkable for the variety and abundance of the minerals which it affords. This is explained, as remarked by Prof. Leonhard, by the wide range of rocks found in the country, embracing not only the older crystalline rocks with their many metallic veins, but also a large variety of igneous rocks, of which those of the Kaiserstuhl are especially rich in minerals, and also a considerable series of sedimentary rocks. The descriptions of

the individual minerals by Prof. Leonhard are concise and yet complete, and doubtless the work will prove highly valuable to those who have occasion to use it. E. S. D.

21. *Studien über Mineral-Pseudomorphosen. Inaugural-Dissertation* von F. E. GEINITZ. 56 pp. 8vo. Stuttgart, 1876.—Dr. Geinitz has subjected a large number of pseudomorphs to a careful study, particularly by means of the microscope, and the results of his work will be read with interest. The pamphlet is illustrated by a plate with a series of figures.

22. *New Minerals.*—Prof. C. U. SHEPARD has named and partially described the following new species:

Vanuxemite. Occurs in small irregular patches scattered through a firm ochery aggregate, proceeding from the decomposition of several zinc ores. Massive, impalpable, with an even or conchoidal fracture. Color white, dull. H.=2·5 – 3, G.=2·5. Does not adhere to the tongue, but emits a feeble clayey odor on being breathed upon. B. B. fuses readily to an opaque enamel. Composition SiO_2 35·64, $\text{A}\!\!\!-\!lO_3$ 11·70, ZnO 32·48–36, H_2O 14·80 –19·88=99·70. Locality, Sterling Hill, N. J.

Keatingine. Considered "probably a new species." Closely resembles fowlerite in crystalline structure, but angles obtained on cleavage prisms 64° and 116°. Does not lose luster on weathering. H.=4·5 – 5, G.=3·33. B. B. fuses to a reddish semi-transparent glass. Composition SiO_2 47·8, MnO 27·7, ZnO 5·6, CaO 18·0, H_2O 0·8=99·9. Locality, Franklin, N. J., where it was found in a mass of yellow garnet.

Calcozincite. Massive, fine-granular; interpenetrated with fibres of asbestus and sussexite. Luster vitreous. Color light orange-red. Streak lemon-yellow. Translucent. H.=3·5, G.=3·95. Effervesces slightly with acid. B. B. blackens. Composition ZnO 81·00, CaO 7·56, CO_2 5·80, H_2O 4·26, MnO tr=98·62.

Euchlorite. Massive, in coarse elongated scales. Color light olive-green. Powder pale green. Luster subpearly. H.=2·5–3, G.=2·71. B. B. fuses with difficulty on thin edges to a greenish-gray enamel. Decomposed by sulphuric acid. Composition SiO_2 35·51 – 38·46, $\text{A}\!\!\!-\!lO_3$ 6·80, FeO 15·52, (MgO 38·07), H_2O 6·10, 100. Locality, Chester, Mass., where it occurs in a layer on both sides of an extensive vein of albite.

Pelhamine. Forms irregular seams and masses sometimes a foot thick at the asbestus mine at Pelham, Mass. Resembles a black serpentine closely. Almost without luster. Powder dark greenish-gray. H.=5·0, G.=2·9 – 3·2. B. B. infusible. Composition SiO_2 38·40, $\text{A}\!\!\!-\!lO_3$ 2·80, FeO 15·52, (MgO 39·88), H_2O 3·40 =100.

Prof. Shepard has also published a catalogue (8 pp.) of the minerals found within seventy-five miles of Amherst College, Mass. E. S. D.

III. Botany and Zoology.

1. *The Structure and Movements of the Leaves of Dionæa muscipula;* by Casimir De Candolle.—A neat paper, separately issued from the Geneva *Archives des Sciences Phys. et Nat.*, April, 1876, illustrated by two plates of anatomical details. One noteworthy suggestion—which has already been made here,—is that the sudden change of electrical current at the closing of the trap, ascertained by Burdon Sanderson (and much insisted on, on account of its accordance with what takes place in muscular motion), may have had its importance much overrated. The electro-capillary currents, which Becquerel long ago demonstrated in vegetable tissues generally, would almost necessarily be influenced in some such way by the displacements of liquid which would accompany any such abrupt change in the turgescence of the parenchyma. In some experiments made three years ago by Professor Trowbridge, of Harvard University (which, unfortunately, were not followed up), it was found that the strong bending of an internode of stem, without lesion, produced a similar electrical effect.

M. Casimir De Candolle fairly deduces from his experiments the conclusion that animal matter is not necessary to the development and vigor of *Dionæa.* He goes on to the conclusion that the animal matter of the insects caught is not directly utilized by the leaves. This does not follow. Very much evidence would be required to rebut the presumption that the organic matters absorbed are somehow (and even directly) utilized by the plant.

The independent movement of the border of the trap with its fringe of bristles is explained by the anatomical structure, which is, as it were, distinct from that of the main body. The glands are stated to belong to the epidermis only; but the excitable bristles are connected by the cellular bulb with the subjacent parenchyma, so that impressions upon the former may readily be transmitted to the latter. The closing of the trap results from the comparatively permanent elastic tension of the largely fibrous external part of the leaf. It opens by counter-action of the parenchyma of the upper or inner side, through turgescence; the closing results from the sudden diminution of the turgescence, in some unexplained way. In other words, the trap is held open, and at the proper moment is let go. A. G.

2. *Diatoms in Wheat-straw.*—The article by Professor P. B. Wilson, in this Journal, for May last, is referred to in Trimen's Journal of Botany for July, with the remark that the asserted discovery "is not very likely to meet with acceptance among botanists." The real nature of the siliceous molds or casts which Professor Wilson took for diatoms must have suggested itself to those familiar with such matters, and would have been indicated to the author of the communication if this had happened to receive attention before insertion. A. G.

3. *An Intoxicating Grass.*—Besides the "Dronk" grass, i. e., Drunk Grass, of the Dutch Colonists in S. Africa, of which we mentioned Dr. Shaw's account a year or two ago, it now appears that there is in Mongolia another grass with a corresponding native name and similar properties. The account of it is given by Dr. Hance, in the July number of Trimen's Journal of Botany, from specimens and information supplied by Dr. Bretschneider, of the Russian legation at Peking. It proves to be a new species of *Stipa*, brought from the Alachan mountains by a Roman Catholic Missionary, whose horses were disabled by its inebriating properties. The wandering Mongols of the region are familiar with this grass, and use vinegar as an antidote. A. G.

4. *Primitiæ Monographiæ Rosarum.*—The third fascicle of this interesting essay by M. Crépin has come to hand. It deals with Asiatic Roses, and throws much light upon them. Our Cherokee Rose is recognized as of Chino-Japanese origin; but he proposes—apparently with reason—to retain Michaux's name of *Rosa lævigata*, on the ground that this cannot have been the original *R. Sinica*. If not, the name *R. lævigata* has priority. *R. acicularis* of Siberia is recognized as a N. American species of high northern regions; where also *R. Davurica* and *R. amblyotis* (one or both) also appear to occur. A classification of the *Cinnamoneæ* Roses is given; in which *R. alpina* and *R. blanda* belong to the series *Subinermes; R. stricta* and *R. acicularis* to the *Aciculares; R. Woodsii, R. Californica, R. laxa, R. cinnamonea*, and *R. amblyotis*, to the *Diacantheæ*. A. G.

5. *Does the Age of a tree influence the time of Leafing?*—Every one knows that very young trees in a nursery are apt to come rather earlier into leaf than full-grown trees of the species. But this is explained by the nearness to the ground and consequent higher temperature. The comparison should be made between the oldest available trees and other well-developed trees of moderate age. M. Alph. De Candolle caused observations of this kind to be made in two old botanic gardens, viz: those of Paris and of Pisa; and the results were negative,—in the Paris cases no difference; in the Pisa cases, an old Gingko and an old Walnut tree leafed earlier than young trees of the species, while the old tree of Horse-chestnut, *Sophora*, Linden, and *Pawlownia* were later than the young trees. A very full series of cases, of different species, would be needed for the elimination of individual peculiarities, often great in this respect. But M. De Candolle is able to refer to better data, viz: to one case in which the date of coming into leaf of a Horse-chestnut tree, has been carefully recorded for sixty-eight years, and another for fifty-seven years; both at Geneva. Of course any differences due to age would be small in comparison with those due to climate, yet they might be expected to be sensible in the long series of years, if age really made any difference. But the figures do not bring to view any tendency to either earlier or later leafing with the advance of years. M. De Candolle's notice is in the *Archives des Sciences de la Bibl. Universelle*, June, 1876. A. G.

6. *Practical Botany, Structural and Systematic; the latter portion being An Analytical Key to the wild Flowering Plants, Trees, Shrubs, ordinary Herbs, Sedges and Grasses of the Northern and Middle United States, east of the Mississippi*; by AUGUST KŒHLER, M.D., Professor of Botany in the College of Pharmacy of the city of New York. 400 pp., 12mo, copiously illustrated. New York. 1876. Henry Holt & Co.—The structural portion of the work occupies ninety-three pages, and is apparently very well worked up. A glossary of eighteen pages follows. The remainder of the volume is a key, which—ignoring classes, orders, and the like, and little mindful of the integrity of genera—leads directly to genus and to species when these are given, and is intended to serve the purpose of a flora or manual. It is on the dichotomal mode; the first couplet distinguishes *Phænogams* from *Cryptogams*; the former are at once divided into those which have flowers inclosed in an involucre, and those which have not; to the former only *Compositæ* are referred—one sees not why. Those without an involucre to several flowers divide next into perfect and diclinous flowers (which is a very variable matter), and so on. A lady botanist of advancing years, who was brought up under the Linnæan system, used to boast that she could find out the name of a plant by that in half the time required to do it through the natural system of classification. We could not gainsay the fact, and it would have been hardly polite to tell her that she knew little more of botany after the operation than before. The Linnæan system, however, is, if we mistake not, a better, and perhaps a surer one than the present substitute. A. G.

7. *Flora of Southwestern Colorado*; by T. S. BRANDEGEE. Reprinted from Hayden's Bulletin of the Geological and Geographical Survey of the Territories, vol. ii, no. 3.—A small pamphlet, containing an excellent contribution to our Botany. In six pages the character of the country and its vegetation along the San Juan, the Mesa Verde, and the sub-alpine neighboring higher regions, is succinctly and clearly sketched, and the dominant plants mentioned. "The Mesa Verde, a plain of 200 square miles, raised nearly a thousand feet above the surrounding country, is a prominent topographical feature of southwestern Colorado. Its surface is perfectly dry, the showers from the La Plata mountains rarely wetting it except upon the northern edge. *Juniperus occidentalis* covers almost the whole mesa, and it is to the abundance of this ungraceful bushy tree that the name of the green mesa is due." "The sub-alpine *Coniferæ* of the southwestern slope are mainly *Abies Engelmanni* and *grandis*. These two species, either together or in forests of one alone, cover the western slope down to the altitude of *Pinus ponderosa*, 9,000 feet, both species large and magnificent trees. *A. Engelmanni* is the only conifer found at the timber line. . . . *Abies concolor* was not seen upon the western slope, and not a tree of *A. grandis* could be found on the eastern slope. *Pinus ponderosa* is abundant at 8,000 feet altitude, and its large trees will furnish a great amount of lumber. *P.*

flexilis is not common; it grows at 8,500 feet, with *P. ponderosa*, *Abies grandis*, *Menziesii*, *Engelmanni* and *Douglasii*, all associated at this altitude." "*Pinus edulis* is said to fruit once in seven years." "The number of phænogamous plants growing in southwestern Colorado will not equal the 900 species that can be found on any similar area of the eastern slope. The impressions received by any one who has noticed the flora of the eastern slope, riding rapidly over southwestern Colorado, below 8,000 feet altitude, are: the great scarcity of all vegetation, the comparative abundance of rosaceous shrubs and *Artemisia tridentata* [sage-bush], the great number of the annual species of *Eriogonum*, the showy blossoms of *Malvaceæ*, and the few species of *Astragalus* and *Pentstenon*. Nevertheless, the characters of four new *Astragali* appear in the accompanying list, and of other new species the number is considerable. A. G.

8. *Darwiniana: Essays and Reviews pertaining to Darwinism;* by Asa Gray. 396 pp. 8vo. New York: 1876. (D. Appleton & Co.)—The first two of the "Essays and Reviews" here collected into a volume, appeared in this Journal in 1860, not long after the publication of Darwin's first work, on the Origin of Species; and the others, subsequently, in this or other Journals of the country, excepting two, which are here first published. The chapters contain a clear exposition of the essential points in "Darwinism," and a discussion of the bearings of evolution-theories on Natural Theology, besides also a full review of the researches of Darwin and others on the subjects of Insectivorous and Climbing plants. The earlier articles were prepared in order to bring before American scientific readers the views set forth in Darwin's first work—not to advocate them; and, throughout the pages, as in all Dr. Gray has written on the subject, there is perfect fairness to both sides of the question. His extensive acquaintance with the plants of the world, and his oft-repeated perplexities—like those of other botanists—over the close relations among the species of some groups, and the difficulty of finding limits to variation, had prepared his mind for a discussion of any theory that might afford light and aid. His exposition of Darwinism was, therefore, the work of one ready to appreciate Darwin's facts and arguments, and ready to withhold assent if they were not satisfactory. In his paper of 1861—Chapter III—he says: "We are not disposed or prepared to take sides for or against the new hypothesis."

The next essay in the series published in 1863, presents some classes of facts connected with variation among plants, and indicates the "set and force of the current" toward a theory of derivation both in the facts and in the author; and the following essay—Chapter V—on the relations of North American to Northeast Asian vegetation, and of both to the Tertiary vegetation of the Arctic regions, first brought out in 1872, in his Address before the American Association, is an argument for the derivation of species from species, offering many strong facts in favor of the

derivation of the modern vegetation of the continents, by some method of variation, from Tertiary species.

At the same time, in the first as well as others of the essays, and especially in the seventh and the last, Dr. Gray argues, with the earnestness of personal faith, against Atheistic evolution, and in favor of design, or a divine purpose, in and throughout nature.

The work is commended to all readers who would understand what Darwinism in its essential features is, and who desire to learn, from one who knows all sides of the question, the relations of the subject to Natural Theology. J. D. D.

9. *Note on Gigantic Cephalopods,—a Correction.* By A. E. VERRILL.—In describing the large Cephalopods from Newfoundland in two former articles,* a serious mistake was made by me in respect to the lingual ribbon, or odontophore, of the specimen (No. 5) of *Architeuthis monachus.* (See this Journal, vol. ix, p. 128, Pl. iv, fig. 6.) The organ described and figured as the odontophore proves not to be that organ, but is doubtless a specialized chitinous portion of the lining of the mouth or pharynx, covered with sharp chitinous teeth and hard granules. The precise original position of this armed membrane I have not yet been able to determine, owing to the mutilation of the adjacent parts before the specimen came into my possession, and my error was largely due to the mutilation, for the armed band described was not adherent except by a slight attachment at one end, and it occupied nearly the position in which the odontophore should have been situated. Nevertheless I was fortunate enough to find, several months after my papers were printed, the genuine *odontophore* among the dirt and debris that had remained in the bottom of the can in which the specimen had originally been sent from Newfoundland. This odontophore is about 70mm. in length, with the dentigerous portion, where widest, about 12mm. in width. The teeth are in seven rows, with an exterior row of small unarmed plates on each side, thus conforming to the arrangement in the other ten-armed cephalopods. The teeth are deep amber-colored and not unlike those of *Loligo* and *Ommastrephes* in form. Those of the median row have three fangs, the central one longest; those on the next row, on either side, have two fangs; while those of the two outer lateral rows on each side are simple, acute and strongly curved. A full description and figures, which have hitherto been delayed by an unusual pressure of other work, will soon be published in this Journal.

In this connection I wish also to record the occurrence of another gigantic species of cephalopod discovered by Mr. W. H. Dall, on the coast of Alaska. He found three specimens thrown upon the beach in April and May, 1872, and made some very valuable drawings of them while fresh He also preserved the pharynx, beak, odontophore, part of the "bone," and portions of the arms of one of the specimens, and has generously placed them in

* This Journal, vol. ix, 1875, pp. 123, 177. Also American Naturalist, vol. ix, Jan. and Feb., 1875, pp. 21, 78.

my hands for examination, together with his drawings, measurements and notes. The largest specimen had a total length of 14 feet, but the ends of the tentacular arms had been destroyed; length from tail to root of arms, 102 inches; to front edge of mantle, 91·5 inches; width across fins, 42 inches; diameter of body, 18 inches; slender portion of tentacular arms remaining, 61 inches; diameter, 2·5 inches; shorter arms (ends and suckers gone), 30 to 40 inches; diameter of eyes, 1·25 inches; length of pen, 89 inches. The eyes were furnished with lids. The few suckers remaining on some of the shorter arms of one specimen were alternate in two rows and agree with those of *Ommastrephes*. The color was reddish, in fine red dots on a white ground, a darker stripe on the outer median line of the arms. Tail acutely pointed. For this species Mr. Dall has proposed the name of *Ommastrephes robustus*. It is probably a genuine *Ommastrephes*, or if not, it is at least an extremely closely allied genus. I hope soon to publish detailed descriptions and figures of this very interesting species, which forms part of the exceedingly valuable collection made by Mr. Dall on the coast of Alaska.

10. *Comparative Zoology, Structural and Systematic*; by JAMES ORTON. New York: Harper & Brothers. 8vo, 384 pp. 350 wood cuts. 1876.—In the preface to this work the author states that "It is designed solely as a manual of instruction. It is not a work of reference, nor a treatise. So far as a book is encyclopediac, it is unfit for a text-book. This is prepared on the principle of 'just enough and no more.' It aims to present clearly, and in a somewhat new form, the established facts and principles of Zoology. All theoretical and debatable points, and every fact or statement, however valuable, which is not absolutely necessary to a clear and adequate conception of the leading principles, are omitted."

Probably very few, if any, zoölogists will admit that the author has succeeded in carrying these ideas into practice, and many may doubt whether, in some cases, failure in this respect may not have been more desirable than success. To have excluded all that is "debatable" or "theoretical" would certainly have very much reduced the size of this volume. And certainly "just enough and no more" is far from applicable to many chapters. The book is in most respects not unlike other similar compilations, and with about the average number of errors and inaccuracies, many of which will doubtless disappear in a second edition, but should have been avoided in the first. More than half of the volume is devoted to the general facts and principles of comparative anatomy and physiology, some portions being treated with perhaps unnecessary fullness, while others of more general importance and interest (e. g., reproduction and embryology) are treated with unnecessary brevity and reserve, due perhaps to the fact, as stated in the preface, of its "being fitted for High Schools and Mixed Schools by its language and illustrations." How far this consideration should be allowed to interfere with a clear statement of the

fundamental facts of biological science is a question upon which teachers are not likely to agree at present. The system of presenting the comparative anatomy before the systematic zoology is a practice by no means new in text books, and one that has its disadvantages as well as its advantages. An intermediate course has been found preferable by the writer. This book is profusely illustrated, but we regret to notice that very few, if any, of the cuts are new, many of them having done much service before in several text books and popular treatises, while a very large proportion have been borrowed from European books, and illustrate foreign animals, even when far better figures of corresponding American species are easily available. Formerly, when but few of our American animals had been well figured, there was some excuse for borrowing and copying the figures of European animals, but the case has been entirely changed within twenty years, for the American species are now very well and very fully figured in numerous works. Prof. S. Tenney has, in this respect, set an excellent example in his Manual of Zoology, where the figures are excellent and mostly from the standard works on American Zoology. It is to be presumed, however, that this glaring defect is to be attributed far more to the publishers than to the author of the present work. The false economy which so often impels American publishers to borrow for text books stale foreign cuts instead of employing fresh and useful ones, drawn from native animals, should be discountenanced by every naturalist. V.

11. *Geographical Variation among North American Mammals, especially in respect to size. Sexual, individual and geographical variation in Leucosticte tephrocotis.* By J. A. ALLEN. Extracted from the Bulletin of the Geological and Geographical Survey of the Territories, Vol. II, No. 4.—In the former paper Mr. Allen contributed a great amount of information on the variation of many of our larger mammals. His conclusions are largely based upon a study of the very large series of skulls belonging to the Smithsonian Institution. He shows that while most northern and Arctic animals decrease in size southward, the reverse of this is true of other species having a southern distribution, and that the same holds good for genera and families as well as for species.* Mr. Allen, in this paper, reverses some of his opinions, expressed in former papers, respecting the identity of some of the North American Mammals with those of Europe. He now admits that the common black bear (*Ursus Americanus*) is a species distinct from the brown bear (*U. arctos*) of Europe, but he states that the barren ground bear is identical with *U. arctos*, and considers the grizzly bear a "subspecies" of the latter. He now admits the American sable to be distinct from all the European forms. The common red fox he considers a "subspecies" of the red fox of Europe. He questions the specific distinctness of the Canada lynx from the bay lynx (*L. rufus*) and regards it as probably only a "subspecies."

* Similar laws have been found by us to hold good for the marine invertebrates of our coasts.

In the second paper the author shows that in all the American species of *Leucosticte* there is really considerable sexual variation, both as to size and color, and that the species also vary geographically. v.

12. *Archivos do Museu Nacional do Rio de Janeiro.* Vol. I. 1st Trimestre. 30 pp. 4to. 1876.—The first number of this new periodical is handsomely printed and illustrated. It contains valuable papers on Brazilian archeology, by Prof. C. F. Hartt, and by Carlos Wiener. v.

13. *Études sur les Echinoïdées*, par S. Lovén, from Kongl. Svenska, Vetenskaps-Akad. Handligar. Vol. ii, No. 7. 4to, with 53 plates. 1875.—This very important work, although published some time ago, has only just reached us. It is mainly devoted to a very thorough and complete study of the skeleton and external organs of the entire group of Echini. A few new forms are also described and figured. v.

14. *Bulletin of the United States National Museum.* No. 5. *Catalogue of the Fishes of the Bermudas*, by G. Brown Goode; No. 6. *Classification of the Collection to illustrate the Animal Resources of the United States*, by G. Brown Goode. 1876.—The former is a very useful contribution to the Ichthyology of Bermuda and our own adjacent waters. It includes descriptions of many species from life, the synonymy, local names, etc.

The second work is a very comprehensive scheme, showing the possibility and manner of making such a collection complete. This system of classification has been carried out in the extensive collections illustrating this department in the Government Building of the Centennial Exhibition. v.

15. *Contributions to the Natural History of Kerguelen Island, made in connection with the U. S. Transit of Venus Expedition*, by J. H. Kidder, M.D. Part II. May, 1876.—This final part contains the Oology, by J. H. Kidder and Dr. Elliott Coues; Botany, the Phænogamia, Filices and Lycopodiaceæ, revised by Prof. A. Gray, the Musci, by Thos. P. James, the Lichens, by Prof. Edw. Tuckerman, the Algæ, by Dr. W. G. Farlow; Geology, including a list of the rocks and minerals, by Dr. F. M. Endlich; Mammals, by Dr. Kidder; Fishes, determined by Prof. Theodore Gill; Mollusks, by W. H. Dall; Insects, by Dr. Kidder, the Diptera having been determined by C. R. Osten Sacken, and the Neuroptera, by Dr. H. A. Hagen; Crustaceans, by Prof. Sidney I. Smith; Annelids and Echinoderms, by A. E. Verrill; Notes on the specimens obtained, by Dr. E. Kershner and Mr. I. Russell, in New Zealand, etc., including minerals, birds, fishes, skulls, hydroids, etc.; and finally, an important study of the comparative anatomy and affinities of *Chionis minor*, by Dr. Kidder and Dr. Coues. The authors constitute a new tribe (*Chionomorphæ*) to include this species and *C. alba.* They also think it necessary to place the former in a new genus (*Chionarchus*). They regard this small and peculiar group as representing an ancient or ancestral type intermediate in some respects between the modern gulls

and plovers. Among the mollusks, Mr. Dall, in addition to other useful matters, describes a new species of *Lepton* (*L. parasiticum*) which lives upon the test of the sea-urchin (*Tripylus cordatus* V.), chiefly along the ambulacra near the mouth; a new genus and species, *Kidderia minuta*, related to *Modiolarca;* and a new genus and species of Chitonidæ (*Hemiarthrum setulosum*) is contributed by Dr. P. P. Carpenter. Mr. Dall also gives a new generic name (*Eatoniella*) to the small Rissoidæ described by Mr. E. A. Smith under the preoccupied name, *Eatonia.* Among the insects, new facts concerning the remarkable wingless diptera are given, and Dr. Hagen has described a new form (*Rhyopsocus eclipticus*). Among the crustaceans, Prof. Smith has described, as new, *Hyale villosa* and *Lysianassa Kidderi*, and as doubtful, *Atylus*(?) *australis* Miers(?), and gives useful notes on other species. Among Annelids, *Nereis antarctica* and *Neottis spectabilis*,* are described as new, with a revision of the characters of the latter genus. Among Echinoderms, *Pentactella lævigata*, *Hemiaster cordatus*,† *Asterias rupicola*, from Kerguelen Island, and *Astrophyton australe* from Tasmania are described as new, while *Ophioglypha hexactis* Smith is also fully described. Of Anthozoa, two species, *Anthopodium australe* V., new sp., and *Primnoella Australasiæ* Gray, both from New Zealand, are described. V.

V. Miscellaneous Scientific Intelligence.

1. *Elements of Physical Manipulation;* by Edward C. Pickering, Prof. Physics Massachusetts Institute of Technology. Part II. pp. x, 316, 8vo. New York, 1876. (Hurd & Houghton.)—In preparing this volume as a completion of the work of which the first part was published three years ago, the author has greatly extended the range of subjects treated, and has included in this portion topics belonging to a number of kindred branches of science. The first 108 pages are devoted to experiments illustrating electricity and heat, with descriptions of the apparatus required and the modes of conducting the various researches. Then follow chapters upon mechanical engineering, meteorology, practical astronomy and lantern projections. At the end are three

* In the Annals and Magazine of Natural History, April, 1876, p. 318, Mr. W. C. McIntosh has published descriptions of several Kerguelen Annelida from the English expedition. The *Nereis Eatoni* described by him, may, perhaps, be the same as our *N. antarctica*, or a sexual form of it; and his *Neottis antarctica*, may be identical with our *N. spectabilis*, but his descriptions are not sufficiently detailed to permit an accurate determination of these points. The tube of his *Neottis* appears to be quite unlike that of ours, but this may be due to difference of locality. Although this part of Dr. Kidder's report had been in type and the proof had been corrected several months previous to its publication, early in May, the paper by Dr. McIntosh has priority of actual publication.

† Mr. A. Agassiz has published, in the Proceedings of the American Academy, an interesting paper on the young stages of this species, found by the writer inhabiting the deep ambulacral furrows of the female specimens, where they were effectually concealed and defended by the longer spines projecting inward from the borders.

appendices, in the first of which certain topics in electricity are treated more fully than in the main portion of the volume, with the addition of a number of important matters pertaining thereto. The second contains a variety of tables and data useful in physical computations. The third is made up of general directions with reference to physical laboratories, a valuable list of works of reference, and an excellent collection of additional experiments, of varying difficulty, and some of them fitted to tax the skill of the best trained student. The same practical good sense is displayed in the selection and arrangement of the subjects as in the first part, and the two volumes constitute not only a very important contribution to the resources of the student, but also an invaluable aid to instructors in physical science. The cuts which accompany the text, though sufficient for the purposes of illustration, are hardly consistent in quality with the rest of the work, and if, in the endeavor to attain clearness and conciseness, the ordinary graces of style have been sometimes sacrificed, the reader will count it no serious imperfection in view of the very substantial excellence of the work. A. W. W.

2. *Treatise on the Mechanical Theory of Heat, and its applications to the Steam Engine, etc.;* by R. S. McCulloch, Civil Engineer and Professor of Mechanics in Washington and Lee University, Va. pp. xii, 288, 8vo. New York, 1876. (Van Nostrand.)—This volume contains a clear and simple mathematical exposition of the modern theory of heat, with many of its applications in practical matters, especially to the steam engine and other machines for the generation of power by means of heat. It begins with an historical sketch, giving an account of the various steps by which the mechanical theory of heat has been developed, and the historical method is kept in view throughout the book. The author in his preface "acknowledges his indebtedness to the profound views of his friend, Prof. W. H. C. Bartlett, whose mathematical exposition of the unity of physical action has been the point of departure of his own labors." A. W. W.

3. *On the Theory of Ventilation;* by F. S. B. Francois de Chaumont, M.D.—In my previous paper (Jan. 28th, 1875) I endeavored to establish a basis for calculating the amount of fresh air necessary to keep an air-space sufficiently pure for health, taking the carbonic acid as the measure. The results showed that the mean amount of carbonic acid as respiratory impurity in air undistinguishable by the sense of smell from fresh external air was under 0·2000 per 1000 volumes. My object in the present note is to call attention to the relative effects of temperature and humidity upon the condition of air, as calculated from the same observations.

Temperature.	Humidity.	Carbonic acid.
63° F.	73 per cent.	0·1943 per 1000 volumes.

If, now, we arrange the observations according as they differ from the above standard of temperature and humidity, and note the record of sensation attached to each, we may ascertain how far

the said record departs (if at all) from what it ought to have been as calculated from the actual CO_2. To do this we may employ the numerical values of the different classes, taking No. 1 (fresh) as unity, thus:—

Class.	Sensation.	Value.
No. 1.	Fresh	1·00
2.	Rather close	2·13
3.	Close	3·46
4.	Extremely close	4·66

Taking each observation and dividing the CO_2 found by the mean quantity of No. 1, viz: 0·1943, we get a number which will give the *theoretical* value of its effect upon the senses; and by comparing this with the *actual* value of the *recorded* sensation, we can note whether the difference is *plus* or *minus*, if any. All observed quantities of CO_2 below 0·1943 are considered equal to that number, and all quantities above 0·9054 as equal to it, as the sense of smell does not seem capable of differentiating quantities except between those limits.

Out of 458 fully recorded cases, 186 gave a recorded sensation *in excess* of the theoretical value—that is, the air seemed less pure than would have been expected from its CO_2. In these the average temperature and humidity were both above Class 1.

152 cases gave a recorded sensation *below* the theoretical value —that is, the air seemed purer than would have been expected from its CO_2. In those cases the average temperature was above, but the average humidity below the mean of Class 1.

120 cases gave a recorded sensation that exactly corresponded with the theoretical value. In those cases the average temperature was above, and the average humidity below the mean of Class 1.

Arranging these results and putting F for the temperature in degrees of Fahrenheit, and H for the humidity per cent, we have:—

$$+58^\circ{\cdot}6\,F + 86\,H = +197.70 \quad [1] \quad \left\{ \begin{array}{l} \text{Aggregate difference of the} \\ \text{recorded and the theoretical value of sensation.} \end{array} \right.$$

$$+230{\cdot}8\,F - 82\,H = -117{\cdot}37 \quad [2] \qquad \text{Do.}$$

$$+244{\cdot}0\,F - 91\,H = 0 \quad [3] \qquad \text{Do.}$$

Adding the two last equations, we have,

$$+474^\circ{\cdot}8\,F - 173\,H = -117{\cdot}37 \quad [4] \qquad \text{Do.}$$

From [1] and [4] we can determine the respective values of F and H, which are as follows:

$$F = 0{\cdot}4730 \qquad H = 1{\cdot}9765$$

Or, stated in terms of CO_2, by multiplying by 0·1943,

$$F = 0{\cdot}0919 \qquad H = 0{\cdot}3833 \text{ per 1000 vols.}$$

Taking F as unity, we have,

$$F : H :: 1{\cdot}000 : 4{\cdot}1789$$

Or an increase of 1 per cent of humidity has as much influence on the condition of an air-space (as judged of by the sense of smell) as a rise of $4°{\cdot}18$ of temperature in Fahrenheit's scale, equal to $2°{\cdot}32$ Centigrade, or $1°{\cdot}86$ Reaumur.

This may be taken as a proof of the powerful influence exercised by a *damp* atmosphere, corroborating the conclusions arrived at by ordinary experience; and it follows that as much care ought to be taken to ensure proper hygrometric conditions as to maintain a sufficiently high temperature. This is especially the case in the wards or chambers of the sick, in which regular observations with the wet and dry-bulb thermometers ought to be made; these would probably give a valuable indication of the condition of the ventilation, either along with or in the absence of other more detailed investigations. Thus a room at the temperature of 60° F. and with 88 per cent of humidity contains 5·1 grains of vapor per cubic foot: suppose the external air to be at 50° F. with the same humidity, 88 per cent; this would give 3·6 grains of vapor per cubic foot; to reduce the humidity in the room to 73 per cent, or 4·2 grains per cubic foot, we must add the following amount of external air,

$$\frac{5{\cdot}1 - 4{\cdot}2}{4{\cdot}2 - 3{\cdot}6} = 1{\cdot}5,$$

or once and a half the volume of air in the room. If the inmates have each 1000 cubic feet of space, it follows that either their supply of fresh air is short by 1500 cubic feet per head per hour, or else that there are sources of excessive humidity within the air-space which demand immediate removal.—*Proceedings Royal Society*, London, May 4, 1876.

4. *Ninth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology.* 54 pp. 8vo.—The report of the Curator, Mr. F. W. PUTNAM, contains an account of the various recent additions to the Museum, the largest of which is the collection from Peru and Bolivia, made by Mr. Alexander Agassiz and Mr. S. W. Garman, during their journey in South America. This collection, obtained at a large expense, was the gift, even to the cost of transportation, of Mr. Agassiz. It includes several mummies, pottery, idols, cloth and articles of clothing, balls of thread, spindles, and other articles connected with weaving, "which art was developed to a very high state by the ancient Peruvians;" also work boxes, ornaments and beads of silver, copper, shell, and stone, fishing nets, and many other articles; all taken from an ancient burial-place at Ancon. The adjoining burial-place at Chancay, afforded Mr. Agassiz about 70 jars, vases, and other vessels, with terra cotta idols and images." The two illustrate well the ceramic art of the ancient people from the central portion of the Peruvian coast. Besides these, the collections contain numerous articles from Pasagua. One of the five crania from Pasagua had been distorted by circular pressure, giving it the pyramidal form of some crania from near Lake Titicaca, while three others were of natural form and

not at all like the broad depressed skulls of Ancon. A large collection of hair was obtained from Pasagua, showing "not only the peculiar modes of braiding, but also the fact that hair other than that belonging naturally to the head was worn to a great extent in the form of 'switches,' and that even these ancient people were familiar with the use of the 'rats' of the modern hair-dressers." Among the other objects from the same place were a hair-comb, a head-dress of feathers, a sinker attached to a fishing-line, large dishes, a cup of basket work, articles of clothing, fishing nets, pottery. Pacasmayo afforded Mr. Agassiz jars and vases of black clay highly ornamented, many having the human form or that of monkeys and other animals moulded over them; and Titicaca, a series of graceful jars, reminding of Etruscan art, and various objects quite different from those of other parts of Peru. The collections also contain numerous articles illustrating the manner of life, etc., of the modern Indians.

The Museum has also received large collections from the Smithsonian Institution from explorations in California, including 100 human crania, stone mortars and pots, a cup of serpentine, etc.

The Geographical Distribution of Animals, by A. R. Wallace. 2 vols. 8vo, with colored maps and many illustrations. 1876. London. (Macmillan & Co.)

Carte Géologique du Bassin Houiller de Liège, par M. Julien de Macar. 1876. Liège. (E. Decq.)

Proceedings of the American Association for the Advancement of Science, 24th Meeting, held at Detroit, Michigan, August, 1875. Salem, 1876.

Contributions from the Laboratory of the State University. On the various methods of separating and determining Baryum, Strontium and Calcium. Part I: Determination of Baryum. By P. Schweitzer, Ph.D., Prof. Analytical and Applied Chemistry. From the Catalogue of the University of the State of Missouri. 36 pp. 8vo. Jefferson City, Missouri, 1876.

Geschichte der Sulfoverbindungen mit besonderer Berücksichtigung der Sulfosäuren der methylirten und äthylirten Aniline. By George Adams Smyth, of Maine. Doctorate Inaugural Dissertation at the Friedrich Wilhelms-Universität, Berlin. 43 pp. 8vo. Berlin, 1876.

Science Primers, edited by Professors Huxley, Roscoe, and Balfour Stewart. VIII. Botany, by J. D. Hooker, C.B., F.R.S. 118 pp. 18mo, with illustrations. 1876. (New York, D. Appleton & Co.)

OBITUARY.

Professor McCheeney, of Missouri, who accompanied the geological party under Professor Shaler to the Cumberland Gap, was killed while in the excavation he had just made in an Indian mound. It seems that the people of the vicinity crowded around the edges, which gave way, and quite a number were precipitated in the hole. When the excavation was cleared out again, it was found that Professor McCheeney was stooping when the accident occurred, the result being that his neck was broken. He died almost immediately.—*Letter of Prof. Shaler, dated Camp Harvard, Cumberland Camp, July* 10.

Edward Newman, F.Z.S., editor of the Zoologist and Entomologist, recently died in London, at the age of seventy-five years.

Ehrenberg, the eminent microscopic investigator of Berlin, died on the twenty-seventh of last June.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXX.—*On Cephalization;* by JAMES D. DANA. Part V. *Cephalization a fundamental principle in the Development of the System of Animal Life.*

THE principle of cephalization has been explained at length in memoirs in former volumes of this Journal,* and to them I would refer for detailed illustrations of the subject. Among these illustrations the attention of the reader is especially called to those from the department of Crustacea, the study of which—occupying more than half of my time between the years 1837 and 1855—brought before me the facts on which it rests. It cannot fail to be perceived, in the review, that, with elevation in grade among the Decapods, for example—passing upward along the line of Macrural forms to the Brachyural (or from the lowest of shrimp-like species to crabs)—there is in general, with the rising grade, an abbreviation relatively of the abdomen, an abbreviation also of the cephalothorax and of the antennæ and other cephalic organs, and a compacting of the structure before and behind; a change in the abdomen from

* For former papers on Cephalization, see this Journal, II. xxii, 14, 1856; xxxv, 65, xxxvi, 1, 159, 321, 440, 1863; xxxvii, 10, 157, 1864; xli, 163, 1866.

One point made in these papers, I would withdraw, viz: that the transfer of the anterior pair of members in Man from the locomotive to the cephalic series is analogous to the transfer which takes place in Crustaceans in passing from the Tetradecapod to the Decapod type, or from the Arachnoid to the Insect type. The latter is plainly a structural transfer, the two anterior pairs of limbs in the Crustacean, or the one in the Insectean class, becoming, by the transfer, strictly cephalic organs (pertaining to the mouth series), and existing thus in a large tribe of species. But in man it is properly only a functional transfer, analogous to cases among spiders and Tetradecapods, where the anterior legs become adapted to serve functionally the mouth or head, without that structural transfer which would place them of itself in the higher order.

an organ of great size and power and chief reliance in locomotion, to one of diminutive size, and no locomotive power; and a change as to the particular pair of legs which is the strongest, from one of the more posterior to the anterior in the series; in other words, that, as grade rises, there is abbreviation behind and before, and thus a concentration of the structure, and a more forward or anterior position in the stronger of the organs of locomotion and prehension. The shrimp and crab are so widely unlike in form that the common eye hardly suspects that they are made up of the same parts or organs arranged in precisely the same order: that the latter is only a shrimp contracted in length, dwindled to almost nothing in its abdomen, and compacted in its mouth organs so that the outer pair makes a well fitting operculum over the others, and shortened in its very long multiarticulate antennæ to a few articulations giving them a length often not a tenth of that of the cephalothorax.

I would refer also to the case among mammals, for an illustration of the same principle—that the lowest forms are those having their locomotive functions located in the posterior parts of the body;* and that in the higher, the forces, or force-organs, are more and more forward in the structure. For example, in the whale—the tail is the propelling organ and is of enormous power and magnitude, and the brain is very small and is situated far from the head extremity in a great mass of flesh and bone furnished with poor organs of sense; a grade up, in the horse or ox, the tail or posterior extremity is no longer an organ of locomotion, and is little more than a caudal whip-lash, and locomotion is performed by organs situated more anteriorly, the legs, and a well-formed head carries a brain which is a vastly higher organ of intelligence than that of the whale—but the legs are simply organs of locomotion, and the hinder are the more powerful; and higher up, in the tiger or cat, the fore-legs—not the hind-legs—are the organs of chief muscular force, and these have higher functions than that of simple locomotion, and, further, the body is proportionally shortened, and the head is shortened anteriorly or in the jaws and approximates thus toward the condition in man. The existence or not

* The fact that fishes have, with few exceptions, the tail as the chief or only locomotive organ, corresponds with their inferior position among Vertebrates. At the same time, it makes the application of the principle of cephalization in determining grade among them quite difficult. In most classes or groups the force-organs constitute a series along the body, and the position of the strongest, and the transfer forward with the rise in grade, is openly manifested. But in nearly all fishes, the tail remains the locomotive organ, with no transfer of its locomotive function to more anterior members, and, therefore, other less obvious and much less certain modes of determining any forward transfer of force are all that remain. And, further, as the conclusions we may arrive at hold good, among all classes of animals, only in case *other conditions in the structure are essentially equal*, the inferences from such evidence can ordinarily extend only to the grade in the family or smaller group to which the species belong.

of a switch-like tail, as in ordinary quadrupeds, has little bearing on the question of degree of cephalization, since the organ is not an organ of locomotion, or one indicating a large posterior development of muscular force. But, approaching man in the system of life, even this seems to have significance.

In accordance with the principle and method illustrated, animals of a given type differ widely as to the conditions and arrangements for action—muscular, sensorial and psychical—in the animal structure. In the low,* there is, usually, large size and strength behind, an elongation of the whole structure, and a low degree of compactness in the parts before and behind; in the high, there is a relatively shorter and more compacted structure, a more forward distribution of the muscular forces or arrangements, and a better head; and the progress in grade, under a type, is progress along lines from the former condition toward the latter, that is, progress in the strength, perfection and dominance of the anterior or cephalic extremity; in a word, it is progress in cephalization.

The principle of cephalization is thus fundamental because, first, the chief center of nervous power or energy in an animal is at the cephalic extremity; and, secondly, because form in nature's species is, with some limitations, an expression of force.*

Again, I have exemplified, in my memoirs, the corresponding fact that progress in cephalization generally attends progress in embryonic development; referring, for illustration, to the loss of the locomotive tail in the frog and many other Amphibians at the time of the passage to the adult stage, and the concurrent development anteriorly of limbs, with the perfecting of the head in structure and senses; to a similar abbreviation posteriorly in the development of modern gars; to the fact that the higher insects rise from a state that is worm-like in form, having no distinction of thorax and abdomen and sometimes furnished with abdominal locomotive appendages, to an adult stage in which the abdomen is greatly dwindled in size, the thorax and abdomen are distinct segments and the former alone has locomotive members and these of perfected structure, and the well-defined head has highly developed sense-organs and exalted senses; and to other examples, all illustrating the view that through the developments going forward in the progress of embryonic development, there may in general be distinguished a cephalization, or forward improvement, of the structure.

It has also been illustrated that the geological progress in the life of the world has been progress in accordance with the principle of cephalization, this being manifested in the succession of forms under the various types, and also in the correspondence

* **For a consideration of the inferior species of some groups, related to half-developed embryonic forms in structure, I would refer to my former papers.**

so often exhibited in a general way—as announced by Agassiz—between the biological succession and embryonic development. I need not dwell on the facts in this place, as they are well understood.

Professor Marsh has recently brought forward facts which exemplify fully the view that the succession in the animal life of the globe has been more or less connected with brain-progress, facts which sustain strongly the doctrine, which I have elsewhere urged, that this progress involved changes in structures in obedience to the principle of cephalization.*

Professor Marsh states† that in the Eocene Dinoceras, from the Rocky Mountain region, the brain was not more than one-eighth the bulk of that of the modern Rhinoceros—its nearest recent ally; in the Miocene Brontotherium it was much larger, about equalling that of the Indian Rhinoceros; and in a Pliocene Mastodon, the brain was larger than in Brontotherium, but not equal to that of living Proboscidians. In a paper on the Eocene Coryphodon of the same region,‡ the brain was even lower than in Dinoceras. Again, after a further study of the subject,§ and a comparison of an extensive series of ancient and modern crania, he gives as his conclusions—in advance of a full and illustrated memoir on the subject: "*First*, all Tertiary Mammals had small brains; *second*, there was a gradual increase in the size of the brain during the age; *third*, this increase was mainly confined to the cerebral hemispheres, or higher portions of the brain; *fourth*, in some groups the convolutions of the brain have become more complicated; *fifth*, in some, the cerebellum and olfactory lobes have even diminished in size;" and, further, "there is some evidence that the same general law of brain-growth holds good for birds and reptiles from the Cretaceous to the present time."

A growth of eight fold in bulk since the early Tertiary is enormous, vastly exceeding in amount the growth in other organs; in fact, the species related to the Rhinoceros have not increased in bulk with the progress of time, but diminished. And the same is true of other species; there is in general higher grade *with smaller bulk*. Moreover, concurrently with the change in the brain, there has been in succeeding species a relative shortening of the head and especially of the jaws, besides other modifications, such as mark a rising grade of cephalization.¶

* Author's Manual of Geology, 1874, p. 596.

† This Journal, III, viii, 66, 1874, and xi, 163, with figures of the Dinoceras brain; xi, 335, with figures of the brain in Brontotherium; and xi, 425, with figures of the brain in the Eocene Coryphodon.

‡ Ibid., xi, 425, 1876. § Ibid., xii, 61, July, 1876.

¶ The jaws are in some mammals relatively short through the incisor portion being imperfectly developed, and this condition is a mark of inferior grade. The shortening referred to above is not of this degradational kind, but that presented in a diminished distance between the normal incisor-extremity and the normal position of the posterior molar—an abbreviation which reaches its extreme limit in man.

But have other peculiarities of the later species any connection with this growth and change of brain? We can hardly doubt, that, inasmuch as there has been no corresponding change in the animal's bulk, there must have been concordant changes somewhere, and change of equal magnitude and importance; and the supposition that they included the structural modifications which mark the line of species from the early Tertiary onward, does not appear to be extravagant.

Such growth or progress in the brain and nervous system—the seat of power in the animal—is accordant with, and consequent upon, the great fact that this is the part of the structure which comes into actual contact with outside and inside nature. It is the means in an animal by which communication is had with the outer world and also with its own inner workings and appetites; that which takes impressions, which feels whatever inspires energy, prompts to action, exhilarates, or exalts; the part, therefore, which must grow whenever circumstances favor progress, and, at the same time, fail to grow or dwindle under unfavorable circumstances; which communicates whatever it receives to the being to which it belongs, and, in each case, to the part or parts responding to its condition; which reaches every part of the system and dominates in all action and growth, and hence must cause an expression of its own condition in some way on the structure; which, moreover, must ordinarily produce correlate changes in correlated parts, if any, because in its own nature and distribution the system of correlation has a full expression. Energetic use gives increasing strength to muscle; and that wonderful strengthening growth in the brain since Eocene times may also have come from use.

It would hence appear that a prominent means of change in species is the action of influences on the brain; that the brain grows and changes and sends its changing forces through the animal; and that this gives progress, or degradation; and hence it is that progress is exhibited in cephalization, and degradation in decephalization. The brain could not grow to the adult stage in the frog without the change in the structure that cotemporaneously takes place; and no more could the brain of a species like a shrimp grow into a brain of the higher grade of a crab without its determining in some sense a concordant higher grade of structure in the animal, involving the loss of locomotion in the abdomen and also other changes.

We recognize, as evidence of upward progress in Man, an increasing height, width and erectness of the forehead, and a shortening of his jaws, and see therein evidence of improved intellect; which means higher grade of cephalization. But, more than this, the erect form of Man, the shortened arms, the naked skin, as well as the large, smooth-surfaced cranium, may

also be as directly and necessarily connected with, and dependant upon, his superior degree of cephalization in the system of animal life; while the hairy skin, the long arms, the crested skull, the inclined posture of the man-ape, may be all involved in the ape's inferior degree of cephalization. If so, the development of the brain in Man and of all the highest structural perfections of the Vertebrate type which he exhibits is inconsistent with the existense of the hairy covering and some other circumferential as well as interior characteristics of the brute.

We may therefore believe that in all progress in grade, upward or downward, there was involved some changes in the animal structure of the kind expressing degree of cephalization. Brain-progress could not have taken place without structural progress: and with the brain eminently the growing organ, the brain-progress would have had a determining relation to the latter. More than this, many peculiarities of form or structure in animals which are not evidently marks of grade in cephalization, or have little or nothing to do with it, may have had the same source. The type of structure characteristic of a group of species is beyond doubt connected with some peculiarity of chemical composition, or rather of chemical compounds present, in the great center of activity; and this chemical condition once established, the progress afterward, connected with brain growth or change, might well be a development in that line of type structure, displaying the type under new forms.

I do not mean to imply, in the above, that the method of progress pointed out accounts for the existence of the various types of structure in the animal kingdom, or for all the developments under them: but only that, whatever the types of structure in course of development, there was also a general subordination in the changes to the principle of cephalization; because the nervous system by its growth and domination must necessarily have determined such subordination; and, further, that, through the same agency, the development of other peculiarities of structure and form, not obviously marks of grade, may have been occasioned. The origin of the grander types of structure must be connected with the profoundest of molecular laws; and how connected, man may never know.

These views may hold whatever be the true method of evolution. The method by repeated creations through communications of Divine power to nature should be subordinated, as much as any other, to molecular law and all laws of growth; for molecular law is the profoundest expression of the Divine will, the very essence of nature; and no department of nature is without its appointed law of development. But the present state of science favors the view of "progress through the derivation of species from species, with few occasions for Divine

intervention."* If then there has been derivation of species from species, we may believe that all actual struggles and rivalries among animals, leading to a "survival of the fittest," must tend, as in Man, to progress in cephalization, and dependent structural changes. In fact, mere living, the surmounting of the daily obstacles in getting food and shelter and satisfying ordinary desires, may have given growth to the brains and structures of the Eocene mammals, aiding, but perhaps exceeding, all other influences from environments.

The source of variation here pointed out is not at all at variance with Darwinism. Darwin, in fact, does not aim to explain the origin of variation among species, but chiefly the workings of natural selection—variations being in progress by some means—in leading to the "survival of the fittest" of the varieties. Variation he refers to environments, and especially to action on the genital system. The genital system may have this prominence in plants; but for animals I would give the *nervous* system the higher place, inasmuch as upon it environments make their first and most powerful impress.

One reason why plants present but few simple types of structure compared with animals, and why marine plants are almost the same for all geological time, and thus strongly contrast with the immense diversity and complexity of types and kinds among marine animals, may be found in the fact that plants possess not that feeling, knowing, outreaching and inworking thing, a nervous system. This, however, is not all: for the presence of so large a proportion of nitrogen in the animal structure, in addition to other elements, gives an opportunity for a vastly wider range of chemical combinations.

ART. XXXI.—*On an Electro-magnetic Machine constructed at the Cornell University Workshop*; by WM. A. ANTHONY, Professor of Physics at the Cornell University.

THIS machine is essentially the same as the "Gramme" electro-magnetic machine, and its construction was undertaken on account of the difficulty that seemed to exist in the way of procuring the "Gramme" machine from the European manufacturers.

The soft iron core of the revolving armature consists of a coil 24 cm. external diameter, 20 cm. internal diameter, and 15 cm.

* This sentence is cited from my Manual of Geology, 1874, p. 603. After it come these words:—"For the development of Man, gifted with high reason and will, and thus made a power above Nature, there was required, as Wallace has urged, the special act of a Being above Nature, whose supreme will is not only the source of natural law, but the working force of Nature herself," and this I still hold.

wide, of very soft iron wire 3 mm. *square.* To prevent, as far as possible, the formation of induced currents in the coil itself, which would consume power to no purpose, the wire, while being wound into the coil, was drawn through a thick shellac varnish, which, it was thought, would to a certain extent insulate the adjacent wires from each other.

The conducting wire of the armature consists of 100 coils, each of 4 meters, of cotton-covered copper wire 2 mm. square. These coils terminate alternately on the right and left of the armature, and each set is connected with fifty copper strips which surround the axis and serve to transmit the current in the usual way. The two sets of coils are entirely independent of each other, and constitute practically two distinct armatures. The resistance of each armature as employed in the machine is very nearly $\frac{1}{4}$ of an ohm.

The cores of the two inducing magnets are 7·5 cm. diameter, 60 cm. long. At the middle of each is a block of cast iron which serves as the magnetic pole, 15 cm. wide, and embracing about one-third of the circumference of the armature. On each end of the cores is a bobbin 25 cm. long and 15 cm. diameter, wound with eight layers of copper wire 3·5 mm. square. The eight layers are not joined on the bobbins, but form so many independent conductors, the terminals of which are carried to a commutator on the base of the machine. The commutator serves to combine the wires into one continuous conductor having a resistance a little less than one ohm, or into 4, 8 or 32 conductors in multiple arc.

The wires from the four brushes which collect the currents from the armatures are carried to another commutator, which serves to join the two armatures in series or in multiple arc with the coils of the inducing magnet in the main circuit, or to put one armature in circuit with the magnet coils, while the other communicates with the terminals of the machine and furnishes the useful current.

Preparations were commenced for making a complete series of tests of the working of the machine, but it had been decided to send the machine to the Centennial exhibition, and, as the preparations could not be completed in time, only a few tests were made. Large German-silver wires were stretched across the room to serve as resistance, as described by Professor Pickering in his account of the tests of the Farmer machine at the Institute of Technology in Boston. For measuring the currents, a tangent galvanometer was especially constructed, and its constants determined from a large number of experiments with the copper voltameter.

The tables below give some of the results of the experiments. The observations and computations were made under my direction, principally by Mr. M. M. Garver, now a graduate of this

University in the department of Chemistry and Physics. More extended tests will be made after the machine returns from the exhibition, when a dynamometer will be procured to measure the power consumed.

TABLE I.

Armatures joined in series; resistance $\frac{1}{4}$ ohm.
Magnetic coils joined in series; resistance 1 ohm (nearly).

No. of revolutions per minute.	E. M. F. Volts.	Total resistance. Ohms.	Current. Webers.
543	68·9	6·74	10·22
572	54·05	11·06	4·91
560	5·17	141·5	·0364
419	36·85	11·06	3·35

TABLE II.

One armature supplying the useful current, the other in circuit with magnet coils which were joined in series.

No. of revolutions per minute.	E. M. F. Volts.	Total resistance of useful circuit. Ohms.	Useful current. Webers.
323	24·1	4·39	5·49
319	23·8	3·67	6·50
313	23·34	2·82	8·27
309	23·28	2·65	8·78
309	23·17	9·81	2·36
309	25·1	19·19	1·31
309	25·8	62·95	·40
279	18·7	62·95	·30
279	16·6	2·82	5·88

Only one experiment with the armatures in multiple arc was performed, and in this, a water voltameter, having platinum plates 6 x 8 cm. enclosed in separate tubes to deliver the two gases separately, was included in the circuit. The magnet coils were joined to give four circuits in multiple arc, having a resistance altogether of $\frac{1}{16}$ ohm. The resistance of the armatures in multiple arc is $\frac{1}{8}$ ohm. Hydrogen gas was delivered at the rate of 257 c.c. per minute, which corresponds to a current of about 43 Webers. The speed in this experiment was not recorded, but could not have been far from 320 revolutions per minute. I speak of the experiment only to show the range of adaptability of the machine.

A series of experiments was made to determine the character of the light produced by the machine, with the following general result:

Number of revolutions per minute,	487 to 525.
Current by galvanometer,	10·5 to 11·5 Webers.
Resistance of light, about	4 ohms.
Entire resistance,	5·65 ohms.
Intensity of light (average),	1600 candles.

The intensity of the light was determined by first comparing it with that of a coal-oil lamp and then comparing the latter with a standard candle.

In all these experiments the machine was driven by a five horse power oil engine, known as "Brayton's Ready Motor," built by the "New York and New Jersey Ready Motor Company." An interesting fact appeared upon comparing the oil used by the engine with that consumed by the lamp used for comparison with the electric light. The lamp had a flat wick one inch wide. This was carefully trimmed and the light carefully adjusted before the experiments. The experiments continued four and a half hours, during which time the lamp burned continuously. The lamp consumed per hour 29·8 grms. of oil. The electric light was equivalent to 234 lamps, that is, equivalent to the light produced by the combustion of 6973 grms. of oil per hour. The engine consumed three kilograms of a light gravity crude petroleum per hour.

It would seem, therefore, that the combustion of the oil in the engine produces, after the transformation of the energy evolved, first into mechanical power, then into the electric current, and lastly into light, nearly three times as much light as when consumed in the ordinary lamps.

I would add that, while the machine produces a very efficient light, which I have used with great satisfaction in my lectures, it is not so well adapted as it might be to this particular purpose. The electro-motive force developed is too small, and the internal resistance of the machine too small, for the best effect with the light. The small resistance of the machine makes the regulation of the light difficult. (The regulator used was the Foucault.) For, the light being about two-thirds the resistance of the circuit, any change in the relative position of the carbons, changes materially the entire resistance, and this, since the coils of the inducing magnet are in the main circuit, makes a very great difference with the current.

To make a more perfect machine for the production of the light and retain the advantages it now possesses for other purposes, it is proposed to construct a new armature, using finer wire and a greater number of coils, and connect the terminals of these with a commutator that will permit them to be joined in series as usual, or in multiple arc in groups of two or three, these groups being joined in series as though they were single coils. Such an arrangement will produce a machine which can be readily adapted to the various conditions of external resistance met with in electrical experiments.

Physical Department, Cornell University, Ithaca, N. Y., July 24, 1876.

ART. XXXII.—*On the Sea-bottom Deposits observed during the Cruise of the Challenger in a report to Prof. Wyville Thomson;* by JOHN MURRAY, Esq., naturalist of the expedition.*

THE kinds of deposits obtained in soundings by the Challenger, may for the present be classed under the following heads:—

1. *Shore-deposits.*
   (*a*) Blue and green muds.—Met with near the shores of most of the great continents and islands.
   (*b*) Gray muds and sands.—Met with chiefly near oceanic islands of volcanic origin.
   (*c*) Red mud.—Met with on the eastern coast of South America.
   (*d*) Coral-mud.—Met with near coral reefs.
2. *Globigerina-ooze.*—An abundant oceanic deposit not met with south of latitude 50° S.
3. *Radiolarian ooze.*—An oceanic deposit met with only in the Western and Middle Pacific
4. *Diatomaceous ooze.*—An oceanic deposit met with only south of 50° S. latitude.
5. *Red and Gray Clays.*—The most abundant oceanic deposit.

The above names have been selected as indicating those elements which give the predominating character of the deposit. As a rule, when the débris of continents or islands, the dead shells of Foraminifera, the exuviæ of Radiolarians, etc., the frustules of Diatoms, or red or gray clayey matter—when any of these have appeared to make up considerably more than one half of the specimen under examination, it has been called a shore-deposit, a Globigerina, Radiolarian, or Diatom ooze, or red or gray clay.

Sometimes it has been doubtful whether a specimen should be placed under one of the above heads or another, on account of the nearly equal ratio of constituents, or where one deposit overlies another of a different kind. In these cases the specimen has been placed under that head with which, on a general view, it has seemed to have most in common, or to which the surface-layer belonged, and a detailed description has been added in the list.

A sixth kind of deposit or formation might have been added, to embrace those bottoms in which a great quantity of the *peroxide of manganese* occurs. This substance, in the form of

* From the Proceedings of the Royal Society, vol. xxiv, No. 170. The general remarks here cited are preceded in the Report by detailed descriptions of each of the soundings in the course of the expedition. These notes and conclusions are from a preliminary report, which is soon to be followed, now that the expedition has returned, with a fuller statement.—EDS.

nodules or concretions, of incrustations or in grains, has been found in nearly all sea-deposits and at all depths in more or less abundance. However, for the present it has been considered best to treat of its occurrence separately, at the same time pointing out those regions where we have found it in greatest abundance.

A few remarks may now be made upon each of the kinds of deposits indicated.

1. *Shore-deposits.*—It has been found that the deposits taking place near continents and islands have received their chief characteristic from the presence of the débris of adjacent lands. In some cases these deposits extend more than 150 miles from the coast. Several varieties can be recognized among these shore-deposits.

(*a*) *Blue and Green Muds.*—In the great majority of cases the deposits near continents and large islands, containing the older and crystalline rocks, have been of a blue or green color; the only exception appears to be the east coast of South America, where we have a red mud, to be presently referred to.

In from 100 to 700 fathoms these deposits are often of a green color, due to the presence of a green amorphous clayey matter, and dark and pale green glauconite particles. Beyond 700 fathoms they are usually of a blue or dark slate-color, having a thin upper layer of a red or brown. This red layer is a soft ooze, whilst the blue mud or clay beneath is very compact and tenacious. Much amorphous clayey matter and fine particles of mica, quartz, and other minerals are found in all these deposits, the mineral particles increasing in size as we approach the land.

Down to 1500 fathoms, we have generally found that Pteropod, larval Gasteropod, and Lamellibranch shells were tolerably abundant, and that there were many of the shore forms of Foraminifera, as Textularias, Rotularias, Nodosarias, Uvigerinas, Lagenas, etc. Pelagic Foraminifera occur throughout the deposit, but not in such abundance as in a true ocean-deposit. The frustules of Diatoms and their broken parts are numerous. Manganese grains are found in many of the bottoms, usually in the deeper soundings. We have also found imbedded in these muds pieces of wood, fruits, portions of fruits, and leaves of trees. Large pieces of rock, as pumice and granite, and rounded pebbles also occur. Our soundings near the southern ice-barrier were muds of a blue color, containing many granitic and other pebbles and blocks, mostly rounded, and many Diatoms, and resembled in most respects the deposits we found off the east coast of North America, Halifax to New York.

Beyond 1500 or 1700 fathoms, Pteropod and Heteropod shells are usually not found, and in 3000 fathoms hardly a Foraminiferous or other carbonate-of-lime organism remains.

Siliceous organisms occur at all depths, but at times their remains would seem to be completely removed.

These green and blue muds have been found to prevail in all the enclosed seas we have visited, as Arafura, Banda, Celebes, and China seas, Inland Sea of Japan; and in all these the carbonate-of-lime organisms would appear to be removed from the bottoms in depths less by some 400 or 500 fathoms than on open coasts.

In the green muds from 50 to 700 fathoms we have found those beautiful casts of Foraminifera, Pteropods, *Echini*-spines, and other carbonate-of-lime organisms, frequently in great numbers. These are of a dark green, pale green, and dirty white color. In all cases where these green internal casts occur we have many glauconite grains in the bottom. Beyond 700 fathoms these casts seldom occur, and when they do they are very sparingly distributed; and the same may be said of the glauconite grains which accompany them. River-muds, in which Pteropods, Radiolaria, and pelagic Foraminifera are usually wanting, are included in these deposits.

The following are the localities in which we have found the blue muds (an asterisk before the locality indicates that glauconite casts and grains have been found there):

* Off coast of Portugal; off Virgin Islands (?); * off coast of North America, Halifax to New York; off Guinea, coast of Africa; * off Cape of Good Hope: off Antarctic ice-barrier; * off Australia; * off New Zealand; * off New Guinea and Phillipines, and throughout the seas of the East-Indian archipelago; * off Japan; off east coast of South America.

The following are the depths of the soundings which have been placed under this head:—

Blue Muds.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
1125	600	2020	1300	40	2100	2000
1290	3875	1750	2200	32	700	1075
1475	2425	2500	400	1100	90	2250
1380	1700	2325	150	700	150	20
1800	1240	1250	140	2800	375	2675
1000	1350	1675	75	1425	2225	1875
525	1340	1800	39	2550	2050	2225
900	1250					

Green Muds.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
470	100	120	400	580	705	245
560	150	650	10	129	185	565
80	2200	950	70	255	37	775
75	290	1200	800	100	152	

(*b*) *Gray Muds and Sands.*—Near volcanic islands we have found that the deposits have a distinctive character, from the presence of the débris of volcanic rocks. The presence of pieces of pumice, scoria, etc., prevents this deposit having that clayey character so characteristic of the blue mud. The color is generally gray, but occasionally is a black sand or a more or less slate-colored mud. In some places the shells of oceanic organisms make up a large part of these muds.

Down to about fifteen hundred fathoms we have Pteropod, Heteropod, and surface Gasteropod shells, and the shore forms of Foraminifera are common. Deeper than 1500 fathoms, Pteropod shells are rare or entirely removed. Pelagic Foraminifera are found at all depths; but occasionally they and the siliceous organisms are quite absent at a depth of little over 2000 fathoms, and then we have a clay or mud with many small particles of pumice, scoria, etc. Manganese appears to be intimately associated with some of these bottoms, especially where the débris of augitic lavas are present, as at Sandwich Islands, Canaries, and elsewhere. Off the Desertas, in 670 fathoms, all the dead shells, pieces of Polyzoa, etc. had a slight coating of this substance, and we have had indications of the same thing in even less depths. In 1100 fathoms off the Canaries some pieces of shell had rather a thick coating; and in 1575 fathoms, not far from this place, the dredge brought up a great quantity of a Gorgonoid axis deeply imbedded in or coated with this black oxide of manganese.

In some localities this deposit extends to a great distance from the islands, as at Hawaii, 200 miles or more.

The following are the depths of the soundings which we have classed as

Gray Mud.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
670	7	1000	260	20 to 100	2150	2650
1150	640	1125	360	75	2600	1525
930	1750	1070	1100	520	1050	420
1500	620	1000	50	630	500	590
278	1890	1675 (?)	150	600	2050	620
630	1525	465	600	1200	2875	680
560	450	675				

Occasionally a few casts of the Foraminifera have been observed of a red color. These were usually very rough, and had not the delicate hues of the green glauconite casts. One very remarkable exception occurs:—off the Crozets there were (in 600 fathoms) many beautiful casts of the carbonate-of-lime organisms of a pale straw-color. None of the glauconite grains were noticed in the same sounding or locality.

(*c*) *Red Mud.*—It has already been stated that the deposit

along the east coast of South America, from Cape San Roque to Bahia, differed from the deposits found along the shores of other continents and large islands in being of a red color. There can be little doubt but that this red color is due to the presence of the ochreous matter carried into the Atlantic by the South American rivers. There are reasons for thinking that the red color of some of the deep-sea clays in this region of the Atlantic may have a like origin.

The soundings near the shore and in shallow water have a deeper red color and contain larger mineral particles and fewer organic remains than those farther from land and in deeper water. The mineral particles are chiefly quartz and mica.

In all these soundings there are many pelagic and other Foraminifera, Heteropod, Pteropod, larval Gasteropod, and Lamellibranch shells, Coccoliths, and Rhabdoliths. Siliceous organic remains, as of Diatoms and Radiolaria, are almost quite absent in these bottoms. In some of the shallower depths a few red-colored casts of Foraminifera were observed; but these were rare, rough, and more or less imperfect.

The following are the depths of the soundings along this coast:—

fms.	fms.	fms.	fms.	fms.
1375	1650	32	1600	1015
500	675	400	1200	1275
2050	120	1715	700	2150

(*d*) *Coral-Mud.*—This is a deposit found in the neighborhood of coral reefs. It is characterized by a large quantity of amorphous calcareous matter, by the débris of coral reefs, by many large calcareous forms of Foraminifera, and by broken pieces of Polyzoa, etc. All the deposits about Bermuda are of this nature, extending from the edge of the reef down to a depth of 2500 fathoms. At 1000 fathoms the mud assumes a rose tinge; this deepens into a red color with greater depth, and the accompanying decrease of carbonate of lime and increase of clayey matter, until the coral-mud merges into the red and gray clays of the surrounding ocean. About Bermuda very few mineral particles were found. In some of the soundings to the S. W. of the island there were some small pieces of a green rock like those at St. Paul's Rocks, and probably serpentine. One or two pieces of quartz, or sanidin, a piece of mica, and a small piece of pumice (?) were also noticed. Dissolving away carbonate of lime in some of the shallower soundings only a trace of clayey matter remained with a perceptible rose tinge. No casts of the Foraminifera were noticed about Bermuda.

At the Virgin Islands, at Tongatabu, at Fiji Islands, at Cape York, Admiralty Islands, Honolulu, and Tahiti we also met with coral-muds. Except at Cape York, these muds appeared

to exist as a narrow band around the land, and had usually a considerable admixture of clayey matter and mineral particles. Where there was much clayey matter we found usually a few rough red casts of the Foraminifera.

The following is a list of the depths of the soundings included under coral-muds:—

At Bermuda.			At other places.		
fms.	fms.	fms.	fms.	fms.	fms.
2250	2100	1250	460	140	25
1820	1950	1575	390	210	100
950	2650	1500	625	610	40
430	1325	200	18	70	90
1375	1075	37	240	25	100
2450			315	16	
			255		

2. *Globigerina-ooze.*—After the deep-sea clays, this is the most abundant deep-sea deposit. It has occurred at all depths from 250 to 2900 fathoms. The *Globigerinæ*, which give at once the name and chief characteristic to this deposit, are really found all over the bottom of the ocean. Even in our deepest clays, if the surface-layers be selected and all the amorphous matter be washed away, one or two shells of some variety of pelagic Foraminifera can usually be detected. By pursuing this method I have failed only on one or two occasions. They appear to be quite absent in the Arafura Sea. It is, however, when they occur in vast numbers that they form the deposit known by this name; at least such is the sense in which it is here used. We did not find a Globigerina-ooze in any of the enclosed seas, in the Southern Ocean south of lat. 50° S., nor in the North Pacific north of latitude 10° N.

In the Southern Ocean only one small species of *Globigerina* was found in the surface-waters; but in the North Pacific many varieties of pelagic Foraminifera abound near the surface of the ocean. In other parts of the preceding oceans, and in the other oceans we have visited, it occurs in irregular patches, being always present in the open ocean when we have depths of less than 1800 fathoms. Its presence or absence at depths beyond 1800 fathoms is, however, determined by conditions at present unknown. A number of varieties occur both as to color and composition. Some specimens are nearly pure white, others have a rose-color, and others are red or dark brown. The red and brown color arises from the presence of the oxides of iron and manganese. In the white varieties the sediment, after dissolving away the carbonate of lime, is in some specimens abundant, in others not abundant, and is either of a red or slate-blue color. We find the former color to prevail in those soundings

far from continents and large islands, and the sediment is not abundant except where pumice or scoria is present. The latter, or slate-blue color, is found in those soundings more or less near continents and large islands; and it is suspected that this sediment has its source chiefly from the disintegration of these adjacent lands.

Mica, quartz, pumice, scoria, and other mineral products are met with; but in those soundings farthest from land a little piece of pumice or scoria may be the only trace of mineral particles.

In some specimens there are very many remains of organisms with siliceous shells, as Radiolaria, Diatoms and Challengerias; but in others these remains are almost entirely wanting. In three soundings in mid-Atlantic, between the Canary and Virgin Islands, and in several soundings in the South Pacific, manganese in the form of grains and nodular concretions is very abundant. As a rule, however, this substance occurs rather sparingly in Globigerina-ooze. In some instances we get little nodules of these bottoms, the shells as it were being run together by a siliceous cement. Many small pieces of cherty-like mineral also occur, which are angular and soft, and do not look as if they had been transported. Manganese nodules occurring in the Globigerina-ooze have often a nucleus of a yellow and green color, in which Globigerina-shells can be seen; but their carbonate of lime has been entirely removed, and replaced by a silicate. There are reasons for thinking that these indications of flint (?) occur only in those samples where the siliceous shells of Radiolaria, Diatoms, etc., are wanting, and do not occur where these organisms are present. A reëxamination of all the bottoms must be made before this statement can be definitely affirmed. Casts of Foraminifera occur very sparingly in Globigerina-ooze; in the purest samples not at all. In those with an admixture of clayey matter we have frequently one or two partial casts of a very rough character. In two soundings, Nos. 211 and 301, in the Pacific, we found the Foraminifera not only filled, but also coated, with a red substance, so that we had both an internal and an external cast, the two being connected by little rods representing the foramina of the shell. In these soundings there was much clayey matter and disintegrating pumice and scoria.

In a few soundings in the Pacific, as No. 304, we have had a Globigerina-ooze on the surface of the bottom, and a foot beneath a nearly pure red or brown clay. Again, as in Nos. 268 and 307, we have the reverse arrangement, a clay occupying the surface, and the deeper layers having many *Globigerinæ*. In all these cases the surface-layer has been normal with the

other soundings in the same region as to depth. In the first case we might bring in elevation to account for the Globigerina-ooze overlying the red clay, or we might suppose that chemical changes are going on in the deeper layers which remove the carbonate of lime. In the second case we may account for a red clay overlying a deposit with many *Globigerinæ* in it by supposing a depression of the bottom after the latter had been laid down; or we may believe that agencies are now removing carbonate of lime from the surface-layer, and that these were not active in some past time.

This deposit occurs, in one sounding, in the Pacific at a depth of 2925 fathoms in mid-ocean. In the eastern part of the Atlantic it occurs also at great depths.

The following is a list of the depths at which we have found a Globigerina-ooze:—

Atlantic Ocean.

fms.	fms.	fms.	fms.	fms.	fms.
1090	1900	2200	1350	1425	2275
1525	1950	1675	900	1650	2475
2250	2325	1675	2025	2300	2200
2225	1420	1240	2660	2300	2150
1945	2575	1000	2675	2400	2275
1975	2450	2500	2400	2400	2050
1150	2475	2275	1500	2075	1900
2300	2175	1850	1900	780	2025
2025					

Southern Ocean.

fms.	fms.	fms.	fms.	fms.	fms.
1900	1570	1375	1600	1800	2150

Pacific Ocean.

1974	1350	1675	2925	1915	1500
1100	1450	2000	2425	1600	1825
275	1700	1100	1940	2025	1775
400	1400	1850	2075		

3. *Radiolarian Ooze.*—Organisms with the siliceous skeletons abound in the surface-waters, and apparently also in the deepest waters, of all the oceans and seas we have visited.* The skeletons of these organisms are found in all, or almost all, the sea-bottoms. Even in those cases where at first sight they would seem to be quite absent, a more careful examination (by dissolving away a large quantity of carbonate of lime where this exists, and examining the sediment by careful washing in the case of clays, etc.) will usually reveal a Radiolarian skeleton, a Diatom frustule, or broken portions of these.

* They are, however, much more numerous in the Pacific than in the Atlantic, especially in the equatorial waters.

It is, however, only in some limited areas that these exuviæ rise into such prominence as to be characteristic of the deposit taking place. Such is the case in the Antarctic, where we have a Diatom-ooze, and in the Western and Middle Pacific, where we have the above deposit.

Our deepest sounding (4475 fathoms or 4575) was a Radiolarian ooze; with the exception of a little amorphous matter, manganese particles, a few yellow cherty-like particles, and some pumice pieces, this bottom was entirely composed of the exuviæ of organisms with siliceous skeletons—as Radiolaria, one or two Diatoms, and some organisms which seem to be undescribed (Challengerias), but which are numerous in the deeper waters of the Pacific.

A section of about three inches came up. The upper two were of a red color, due to the presence of much manganese; the lower one was of a pale straw-color, and contained relatively few manganese grains.

In our trip from the Sandwich Islands to the Society Islands we again met with Radiolarian ooze. Between 7° and 12° north of the equator we came on a patch represented by four soundings, some of these containing not a single *Globigerina;* then just on the equator, in two soundings, one at a depth of 2925 fathoms, we got a Globigerina-ooze containing a good many Radiolaria. Between 2° and 10° south we again had a patch of Radiolarian ooze represented by three soundings, and containing only a few pelagic Foraminifera or their broken parts. The occurrence of this patch of Globigerina-ooze in the position indicated, and the comparative or total absence of the Globigerina-shells in the deposits a little to the north and south of it, is sufficiently curious and significant. It will be well to note that, in the Globigerina-patch, manganese and other mineral particles are much less abundant than in the adjacent Radiolarian. Note also the presence of the south equatorial current and the dip of some isotherms over the Globigerina-patch. One or two soundings to the east of Japan might have been classed under this head; but in them the siliceous remains do not make up over one third of the sample in bulk. Generally it may be said that in the Western and Middle Pacific the siliceous remains of Radiolaria and Diatoms are abundant in the deposits, whereas in the South Pacific and Atlantic they are much less so, or absent in the bottoms.

The following are the depths of the soundings placed under the head of Radiolarian ooze:—

fms.	fms.	fms.	fms.
{ 4575	2700	2250	2350
{ 4475	2900	2600	2750
2750			

4. *Diatomaceous Ooze.*—South of the latitude of the Crozets, on our southern trip, we found Diatoms abundant, both in the surface waters and in the bottom.

About the Crozets, Kerguelen, M'Donald's Islands, and close to the ice-barrier, the frustules of these organisms were very abundant in the soundings, but were masked by much land-débris. Between the parallels of 53° and 63° S., i.e., between the north edge of the ice and the latitude of M'Donald's Islands, we got in three soundings a pale straw-colored deposit, composed principally of the frustules of Diatoms and their broken-down parts. In addition, they contained a good many Radiolarian remains, a few specimens of one small species of *Globigerina*, a few particles of mica, quartz, and granitic pebbles, also a little amorphous blue clayey matter. No manganese particles were noticed. The one of these soundings which is nearest to the ice contains much amorphous clayey matter and larger mineral particles than the other two. When dried this deposit is of a white color, and is very light.

The depths of the soundings referred to above are 1260, 1975, and 1950 fathoms.

5. *Red and Gray Clays.*—By far the most abundant oceanic deposits are the deep-sea clays. These are of a gray, red, or dark chocolate-color, and are found at depths greater than 2000 fathoms. The red and chocolate-colors of many of these clays are due to the presence of oxide of iron in the first and oxide of manganese in the latter instance. Most of them contain some carbonate of lime in the form of Globigerina shells; in one or two instances, however, I have not been able to find a single shell, nor has acid caused the least bubble of effervescence. The remains of siliceous organisms occur also in great numbers in the clays of some regions—so much so that, as I have stated, some of those soundings in the Northwest Pacific which have been classed as clays might have been called Radiolarian ooze. In most places, however, they are nearly or quite absent. These clays are not amorphous in the true sense of the word—not amorphous in the sense in which a chemical precipitate is amorphous. They all contain small white and other colored mineral particles in great abundance—exceedingly small particles, so as to be recognized only under the high powers of the microscope. They contain amorphous matter, it is true; but it is doubtful if this ever makes up so much as a half of any sample in bulk. They also contain larger mineral particles, as quartz, mica, pumice, scoria, peroxide of manganese, and other mineral particles. Quartz and mica particles appear to be present only in some localities, as the North Atlantic and elsewhere. Peroxide of manganese is perhaps always present in the form of grains or nodules, sparingly distributed in some

regions, in others making up nearly a half of the deposit or formation.

Pumice (the common feldspathic or the highly vesicular augitic variety) and scoria appear to be universally distributed over the bottom of the ocean, and to be abundant in most of the deep-sea clays and present in them all. In those clays farthest from continents and islands, sharks' teeth, ear-bones of whales, other bones of whales, and bones of turtles (?) are very frequently found, all these having usually a more or less thick coating of peroxide of manganese. The following are the depths at which we have found these red and gray clays:—

Atlantic.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
2740	2575	3025	2475	2650	2875	2700
2950	2435	2800	2600	2500	2750	2350
2750	2385	2960	2850	2360	2750	2275
2800	2675	2850	2675	2575	2700	2550
3150	3000	2700	2800	2850	2750	2650
2720	2975	2600	2650			

Southern and Pacific Oceans.

fms.	fms.	fms.	fms.	fms.	fms.	fms.
2600	2275	2500	2900	2740	3000	2250
2600	2550	2425	2775	3125	2900	2335
2600	2650	3900	2050	2025	2610	2270
2900	2450	3600	2530	2850	2350	2400
2650	2325	2900	2900	2950	2325	2600
2325	2300	2300	2300	2875	2385	2550
2450	2475	2575	2350	2775	2450	2300
2440	2450	2800	2900	2225	2375	

6. *The Manganese in Deposits.*—The peroxide of manganese, in the form of minute grains, concretions, nodules, aggregations, or incrustations, occurs widely distributed in ocean-deposits. It has been met with most frequently in the deep-sea clays; indeed it seems to be present in all of them, sparingly in some localities, abundantly in others.

It is, however, not confined to these clays; it has been found in most of the other deposits and at all depths greater than 500 fathoms. In the Globigerina- and Radiolarian-ooze and in the clays it usually assumes the forms of minute grains, pellets and nodules. In those bottoms to which it gives a chocolate color, the higher powers of the microscope show small, round, red-brown grains of manganese, often with a dark spot in the center.

The nodules vary from little pellets to masses of a large size and of several pounds in weight. In some regions everything at the bottom, even the bottom itself, would appear to be overlaid by and impregnated with this substance. In the foregoing list, as at No. 318 and elsewhere, some of the nodules have

been described with a little detail. The varieties which are most commonly procured may be here mentioned:

(*a.*) Nodules of a black-brown color throughout, the manganese being laid down in concentric layers, which are evident from their enclosing lines of red clay.

(*b.*) Nodules having a nucleus of pumice which is surrounded by concentric layers, the original nucleus being often very deeply impregnated by spider-like ramifications of the manganese, or nearly the whole pumice may be replaced by manganese. When pieces of bone have formed the nucleus we have much the same state of things. The compact bone of the tympanics of cetaceans does not, however, appear to alter so rapidly as other bone; and hence it may be that we get ear-bones in such great numbers.

Sharks' teeth of all sizes (one was four inches across the base) are frequent, and are sometimes surrounded by concentric layers of nearly an inch in thickness. A siliceous sponge (*Farrea*) was found imbedded in two inches.

A mass of red clay may occupy the center of the nodule. The nucleus is occasionally a mottled yellow-and-green substance, with agate bands in some parts, and *Globigerina*, the carbonate of lime being replaced by silicate in these last. This nucleus can be cut with a knife, like new cheese, or it is hard and brittle, breaking with a conchoidal fracture.

Large flat aggregations occur which seem to have been formed on hardened flat portions of the bottom.

The Globigerina-shells and Radiolaria are at times covered by small specks of the manganese; and in the former these are deposited in the substance of the shell.

In several soundings and dredgings to the southwest of the Canaries we got very many large pieces of a branching Gorgonoid which were deeply coated and impregnated with manganese. This was in a depth of from 1100 to 1575 fathoms.

In 670 fathoms, off the Desertas, the dead shells, pieces of coral, Polyzoa, etc., were all coated with a thin film of the peroxide of manganese; and we have had indications of the same thing in still shallower water.

In some of the Radiolarian oozes, and in other deposits, we have found the manganese more abundant in the upper layers than in the lower, and *vice versâ.*

The following are the localities where we have met the manganese in greatest quantities:

Off the Canary Islands; Mid-Atlantic, between Canary and Virgin Islands; southwest of Australia; north and south of the Sandwich Islands; north of Tahiti; generally in the South Pacific in our course between Tahiti and Valparaiso.

Further observations may show that manganese abounds in those places where we have much of the débris of augitic lavas.

7. *Abyssal Rhizopods, Bathybius.*—The manganese nodules, sharks' teeth, etc., which we got in our deepest trawlings have very frequently small branching tubes, composed of clay and sandy particles, running over their surfaces. These belong to a Rhizopodal organism. The sarcode which fills these tubes contains many large brown pigment-cells, and small bioplasts are collected in clumps at distances along the length of the tube, or are scattered throughout it.

Tubes of a similar nature, but composed of pieces of *Globigerina*, Radiolaria, etc., would appear to be rather abundant on some of the oozes, and to run irregularly over the bottom.

In the clays we always get some arenaceous forms of Foraminifera when there has been a successful haul with the trawl. Their shells are made up of pieces of manganese, clay, and small mineral particles, and they contain the same kind of sarcodic substance as the tubes above referred to.

An attached calcareous form (c. f. *Carpenteria*) has been found in rather deep water, and Biloculinas, Nodosarias, Triloculinas, and other forms have been frequently procured alive. These last have orange-colored pigment-cells, in which respect they resemble surface Rhizopods. A living specimen of *Orbulina* or *Globigerina* undoubtedly from the bottom has not yet been met with.

In the early part of the cruise many attempts were made by all of the naturalists to detect the presence of free protoplasm in or on the bottoms from our soundings and dredgings, but with no definite result. It was undoubted, however, that some specimens of the sea-bottom preserved in spirit assumed a very mobile or jelly-like aspect, and also that flocculent matter was often present.

Mr. Buchanan determined that the flocculent matter was simply the amorphous sulphate of lime precipitated by spirit from the sea-water.* Subsequently a number of experiments were made upon the behavior of this amorphous precipitate when precipitated with different quantities of spirit and when treated with coloring solutions. The precipitate was also examined alone and mixed up with some of the ooze. The ooze was examined at the same time, and in the same manner, but without having been treated with spirit. The results were briefly these:

(*a.*) When sea-water is treated with twice its volume of spirit or less, nearly the whole of the amorphous precipitate assumes the crystalline form in a short time.

* See a paragraph from Mr. Buchanan's report on the following page.

(*b.*) When treated with a great excess of spirit the precipitate remains amorphous, and assumes a gelatinous aspect.

(*c.*) This gelatinous-like sulphate of lime colors with the carmine and iodine solutions, and when mixed with the ooze has, under the microscope, the appearances so minutely described by Häckel.

(*d.*) The ooze washed with distilled water, or taken just as it comes up, and treated in the same manner with coloring-solution, does not show these appearances. The jelly-like aspect and the matter colored with carmine can always be removed from the spirit-preserved specimens of the ooze by treating with distilled water.

(*e.*) In all cases the jelly-like or mobile aspect of the oozes is found to be due to the presence of the flocculent precipitate from the sea-water associated with the ooze.

(*f.*) No free albuminous matter could be detected.

When it is remembered that the original describers worked with spirit-preserved specimens of the bottom, the inference seems fair that *Bathybius* and the amorphous sulphate of lime are identical, and that in placing it among living things, the describers have committed an error.*

* Mr. J. Y. Buchanan, chemist and physicist to the Expedition, makes the following remarks on *Bathybius* in his Report, p. 605 of the Proc. Roy. Soc., vol. xxiv. Read March 16. In connection with carbonic acid I may mention that I have frequently tested waters, and especially bottom-waters, for organic matter. None of the methods in use for determining this substance in drinking-water giving satisfaction when applied to sea-water, I had to content myself with endeavoring to detect its presence. If the jelly-like organism which had been seen by some eminent naturalists in specimens of ocean-bottom and called *Bathybius* really formed, as was believed, an all-pervading organic covering of the sea-bottom, it could hardly fail to show itself when the bottom-water was evaporated to dryness and the residue heated. In the numerous samples of bottom-water which I have so examined, there never was sufficient organic matter to give more than a just perceptible grayish tinge to the residue, without any other signs of carbonization or burning. Meantime my colleague, Mr. Murray, who had been working according to the directions given by the discoverers of *Bathybius*, had actually observed a substance like "coagulated mucus," which answered in every particular, except the want of motion, to the description of the organism; and he found it in such quantity that, if it were really of the supposed organic nature, it must necessarily render the bottom-water so rich in organic matter that its presence would be abundantly evident when the water was treated as above described. There remained, then, but one conclusion, namely, that the body which Mr. Murray had observed was not an organic body at all; and on examining it and its mode of preparation I determined it to be sulphate of lime, which had been eliminated from the sea-water always present in the mud, as an amorphous precipitate, on the addition of spirit of wine. The substance when analyzed consisted of sulphuric acid and lime; and when dissolved in water and the solution allowed to evaporate, it crystallized in the well-known form of gypsum, the crystals being all alike, and there being no amorphous matter among them.

These observations were made chiefly on the voyage from Hong Kong to Yokohama in the first quarter of the year 1875; and it subsequently occurred to me that an approximate determination of the organic substance in sea-water might be effected in the following way: Supposing the amount of carbonic acid in the water to be known, let a little permanganate of potash be added to a sample of it,

8. *Origin of Deep-Sea Clays. Relative rate of Deposition of Deposits. Conclusion.*—The very wide distribution of pumice, vesicular lava, or light scoriæ has been already alluded to. Some of the bottoms which have been classed under the head of clays, as 2900 fathoms south of Tongatabu, are largely made up of pumice in a fine state of division. Pumice or vesicular lavas have, in short, been found in all the kinds of deposits, most abundantly in the vicinity of volcanic islands and in the deep-sea clays. It appears to be universally present, and its disintegration is most probably the chief source of the clayey matter found in oceanic deposits. North of the Sandwich Islands we for several days got small pieces of pumice floating on the surface, most of the pieces being covered with a fungoid growth. In this connection it may be well to remember that Mr. Bates states somewhere that he found pumice rather common, floating on the surface of the Amazons, over a thousand miles from the nearest volcanic region. Many instances are given by Sir Charles Lyell of volcanic ashes having been transported to great distances by the wind.

At Honolulu Mr. Green informed me that *Pele's hair* had been picked up in his garden there after an irruption of Kilauea in Hawaii, a distance of about 180 miles from the crater. If there be an ash after the carbonate of lime is removed by carbonic acid or other agent, this will be another source of the clay.

Mr. Buchanan has determined in the clays the presence of copper, cobalt, and nickel, in addition to iron and manganese. Remembering this, one is tempted to suggest the presence of meteoric or cosmic dust in these deposits.

When we have had a good haul from a red-clay bottom, when the bag comes up full of nodules, tympanic bones, and sharks' teeth, we cannot resist the idea that we are dealing with things of a vast antiquity, and that we have evidences of a very slowly accumulating deposit. When there has been no reason to suppose that the trawl has sunk more than one or two inches in the clay, we have had in the bag over a hundred sharks' teeth and between thirty and forty ear-bones of cetaceans; some of these have been imbedded in over an inch of the manganese, arranged in concentric layers, while others have had just a trace of manganese on them, or none at all. We have every reason to suppose that the aggregation of the manganese around these relics is a very slow process, and that

and let the carbonic acid be determined in the usual way by boiling the solution. If the water contained any easily oxidizable carbon compound, we should obtain more carbonic acid in the second than in the first determination, and the difference would correspond approximately to the amount of organic carbon present. In several waters which I have treated according to this principle, I have found from two to five milligrams of carbon per liter.

consequently the occurrence of these deeply imbedded and recent teeth and tympanics in the same surface-layers argues strongly in favor of an exceedingly slow rate of deposition. These vertebrate remains are most abundant where the manganese abounds, but occur also in the red and gray clays, especially in those the farthest from the land, and where we may suppose the rate of deposition to be reduced to a minimum.

In the Globigerina, Radiolarian, and Diatom oozes we have found during the whole cruise only one or two sharks' teeth and perhaps one tympanic bone. In shore-deposits they were even more rare. These facts, taken with others that will at once suggest themselves, go to show, as might be expected, that the shore-deposits accumulate faster than the organic oozes, and these last faster than the deep-sea clay. The organisms in our Radiolarian ooze appear to resemble very closely, and in their relative proportions, those described from the Barbadoes earth. Those described from the Oran deposit in Algeria are very like those in the blue muds taken along the course of the Japan stream. The Globigerina-oozes which we get in shallow water resemble the chalk much more than those in deeper water, say over 1000 fathoms. It is possible that deposits similar to those taking place in deep water, far away from the great continental anticlines, may never have been elevated into dry land.

In conclusion, large quantities of the various bottoms have been stored with a view to future work, and a large amount of material bearing on the subjects treated of in this Preliminary Report have been accumulated. When these come to be carefully examined and compared, with the aid of appliances and conveniences not to be had on board ship, many of the statements herein made may require to be altered and amended, and other facts and relations, more curious and interesting than any hinted at, may be revealed.

Art. XXXIII.—*On Gmelinite from Nova Scotia;* by A. B. Howe. (Contributions from the Sheffield Laboratory. No. XLII.)

While in Nova Scotia, during the summer of 1875, our party found this comparatively rare mineral in considerable quantities, but of two very distinct and different habits. In order to see if this difference of habit could be accounted for by any difference in chemical constitution, the following analyses were made.

The first variety is from a locality called Two Islands, and presents the general appearance very closely of that from Cape Blomidon, which is nearly opposite to this locality. The rhombohedral planes, R and -1, are very nearly equally developed, and the lateral planes i are very distinct and are striated horizontally. The basal plane O is developed to a varying extent in different crystals, but is plainly discernible on all, unless the crystal is imbedded in the matrix or in another crystal so as to conceal it. The plane 1-2 is occasionally seen and usually has a slightly hollow or concave form, and sometimes is represented by simply a slight groove or line along the edge formed by the intersection of the planes R and -1. The color is a pale flesh-red or a cream-white.

In the variety from Five Islands, a locality distant about eight miles from Two Islands, the general appearance is very different, resembling very much that of acadialite. The planes are nearly the same as in the Two Islands variety, but their relative development is very different. The basal plane O is wholly wanting, and the plane -1 is extremely minute in most cases, being hardly discernible on some crystals. The lateral planes i are still present, or rather a series of them, each individual being small and brilliant, having lost their horizontal striations. One of the most characteristic planes is that truncating the edge between R and -1. This plane 1-2, is distinctly striated parallel to its intersection with the plane R, and is always present, even on the smallest crystals, although in some cases it is very much broken and deeply striated. The whole crystal presents the general form of a nearly perfect rhombohedron, some of the faces being nearly perfect, while others are made up of a number of minute crystals, forming an uneven surface. The color is much deeper and brighter than that of the other varieties. On some of the larger crystals there is evidence of twinning, but these have not yet been examined to ascertain if they are true twins.

In order to compare the composition of the Nova Scotia mineral with that from Bergen Hill, an analysis of the latter was also made, but on account of the lack of sufficient quantity it was not made in duplicate. The habit of this variety was intermediate between the other two. The rhombohedral planes R and -1 are unequally developed though to a less extent than the Five Islands variety, and the basal plane O is wanting. The prismatic plane i-2 was not observed on any of the crystals, although some of the Bergen Hill specimens showed an apparent tendency to put on this plane.

The following angles were measured directly with an application goniometer, and agree pretty closely with those given in Dana's Mineralogy:

$R \wedge R = 112° 27'$, $O \wedge R = O \wedge -1 = 140° 7'$, $R \wedge 1\text{-}2 = - \wedge 1\text{-}2 = 161° 10'$,* $R \wedge -1$ pyr. $= 142° 20'$, $R \wedge -1$ bas. $= 79° 27'$.

The following are the results of the three analyses:

Two Islands variety.

			Mean.
Silica	51·36	51·35	51·36
Alumina	17·85	17·77	17·81
Ferric oxide	·15	·16	·15
Lime	5·66	5·70	5·68
Soda	3·90	3·94	3·92
Potash	·24	·21	·23
Water	20·96	20·97	20·96
	100·12	100·10	100·11

Bergen Hill variety.

Silica	48·67
Alumina	18·72
Ferric oxide	·10
Lime	2·60
Soda	9.14
Potash	trace
Water	21·35
	100·58

This analysis is inserted between those of the Two Islands and the Five Islands varieties because it is intermediate between them.

Five Islands variety.

			Mean.
Silica	50·47	50·44	50·45
Alumina	18·26	18·29	18·27
Ferric oxide	·16	·17	·17
Lime	1·13	1·10	1·12
Soda	9·75	9·83	9·79
Potash	·19	·21	·20
Water	20·72	20·71	20·71
	100·68	100·75	100·71

These three analyses give the following atomic ratios respectively:

	Na(K) : Ca,	Ca : Al,	R : Al : Si, (2 Na=R)	Si : H.
Two Islands	1·2 : 1	1 : 1·7	·97 : 1 : 4·9	1 : 2.7
Bergen Hill	6·1 : 1	1 : 4	1 : 1 : 4·5	1 : 2·9
Five Islands	15·4 : 1	1 : 8·8	1 : 1 : 4·7	1 : 2·8

The ratios which Rammelsberg gives as the theoretical are R : Al : Si = 1 : 1 : 4 and Si : H = 1 : 3.† On comparing these

* Five Islands. The others from Two Islands. Calculated from measurement of 1-2 ∧ 1-2.

† Rammelsberg's Handbuch der Mineralogie, p. 626.

analyses with those given by Rammelsberg, it will be seen that, like the majority of those, they give an excess of silica over that required by the ration 1 : 1 : 4. This excess is very marked in the Nova Scotia varieties, but in these it may be partly accounted for by a slight decomposition which may have taken place. The Bergen Hill crystals, however, were very evidently sound and undecomposed, and the excess in this case can not be accounted for in that way.

Both the Nova Scotia varieties had apparently undergone a slight alteration. The crystals were somewhat porous and hollow, and thus would be exposed to easy decomposition; or this structure may have been the result of alteration. Thin sections examined under the microscope with polarized light afforded no evidence of free quartz. If the bases had been removed during decomposition, they had been removed in the proportion in which they existed in the mineral originally, for the ratio of R : Al is closely alike in all the varieties. The excess of silica may have been left in such a form by the decomposition that it would not show itself under the polarizer. The crystals from Bergen Hill however were perfectly sound and unaltered. They gave a very perfect hexagonal and also a basal cleavage, as did the other varieties though not so easily as this. The basal cleavage is not so readily obtained as the prismatic. On treating the finely ground mineral with hydrochloric acid, decomposition with separation of finely-divided silica took place, but there were no traces of gelatinization.

Several experiments were made on the loss of water by heating, but with no satisfactory results. The mineral, even when in coarse fragments, loses weight steadily in dried air at the ordinary temperature. At the end of eleven days over oil of vitriol it had lost about 4 per cent and was still losing at a nearly constant rate. After two days drying at a temperature of 100° C., a constant weight was reached which gave a loss of 7·65 per cent. A constant weight was obtained at a temperature of 115°–120° C., giving 8·82 per cent loss. Another was also found at 160°–180° corresponding to a loss of 17·02 per cent. Still others were found at 200°–210° and at 250° equal to 19·42 and 20·40 per cent respectively. At every temperature mentioned the loss was rather rapid at first, gradually becoming slower and slower till a constant weight was obtained. Apparently the mineral possesses the property of giving a constant weight at any temperature, which may account for the very various results which other experimenters have obtained. The water is driven off completely at a red heat, and the powder becomes sintered together into a mass but without absolute fusion.

It is interesting to notice the fact that the habit of crystalli-

zation corresponds to the difference in chemical composition, at least so far as these three varieties are concerned. In the specimens from Five Islands, in which the protoxide bases are almost wholly made up of soda, the crystal is decidedly rhombohedral in character; the plane -1 is exceedingly minute and the basal plane O is wholly wanting. In the Bergen Hill crystals which were used in the analyses, and are intermediate in composition between the other two, the crystals have not so decidedly a rhombohedral appearance, although R and -1 are very unequally developed. In the crystals from Two Islands, where the lime nearly equals the soda, the planes R and -1 are very nearly equal in size and the basal plane O has made its appearance. The question what change in the crystalline habit a further increase of lime would produce is an interesting one, but must remain unanswered till specimens containing more lime are analyzed and described.

ART. XXXIV.—*On the occurrence of Durangite in the tin-bearing region of Durango, Mexico;* by HENRY G. HANKS.

UP to the present time no account of the mode of occurrence of durangite has been published. Although I have made persistent effort to learn some facts bearing on this subject during the last seven years, since the first description appeared in this Journal, I have never been able to obtain anything reliable until now.

It has been stated in a general way, that this rare mineral was found with stream tin in Durango, Mexico; but as the hardness of durangite is only 5, it has heretofore been impossible to account for the perfect state of the crystals as they reach us.

I am able at last to throw some light on this subject, deriving my information from Mr. J. F. Boyd, of Durango, and Mr. Ayres, of Coneto, Mexico, both of whom have lately visited San Francisco. According to these gentlemen, durangite has been found only in the "Barranca" tin mine and never in the beds of streams. The tin fields in which this mine is located lie about eighteen miles northwestwardly from Coneto, State of Durango, Mexico, and about ninety miles in the same direction from the city of Durango. This would locate them nearly in lat. 23° 30′ north, long. 104° 30′ west. The mines are embraced in a circle which could be swept by a radius of thirteen miles. The whole area is cut up by arroyos, varying in width from ten to one hundred and fifty feet, and of unequal depth. In the beds of these arroyos, through all of which water runs during a por-

tion of the year, and in a few of them during the whole of the year, stream tin is found underlying sand and gravel. The tin ore is sometimes found in bars or flats, sometimes mixed with the surface earth; but generally at a depth of six to ten feet beds of tin pebbles are found. In exceptional cases deposits two feet in thickness have been uncovered, presenting the appearance of a gravel pavement.

Crossing the arroyos, veins of tin occur in threads and seams, from a few inches up to several feet in thickness. All the larger veins have smaller and richer ones intersecting them. One well-known vein is from forty to sixty inches thick, yielding from twenty to twenty-six per cent of tin stone, while the smaller veins crossing it produce as high as sixty-eight per cent with the same treatment.

The tin ore is invariably found in what Mr. Boyd describes as a "whitish cement" which softens readily in water, allowing the cassiterite to fall to the bottom of the washing troughs. Mr. Boyd thinks the character of this formation controls the purity of the tin. When it has a yellowish shade he expects to find the tin contaminated with arsenic, iron, and bismuth. If light gray or white, he notices that the vegetation is stunted, but the character of the tin produced is much improved. Ores yielding from eighteen to thirty per cent are very abundant, but do not pay to smelt without concentration. Associated with the tin ores are found fluor spar, calcite, chalcedony, and topaz.

The altitude of these tin fields is from nine thousand to ten thousand feet. All the hills are beautifully overgrown with grass and shrubbery. The mines occur in a crust of a lighter color than that of the general country. This formation is from seven hundred to twelve hundred feet in thickness overlying the gold, silver and lead-producing formation. Sometimes a high hill or mountain top is seen to be capped with the tin formation.

Over the entire tin fields prospecting holes have been sunk, the bed rock being reached at a depth varying from three to ten feet. These shafts have never failed to develop stream tin in greater or less quantities. During the wet season, commencing in the middle of June, great quantities of rain fall. Advantage is taken of the abundance of water to sluice out the stream tin, to be smelted during the dry season. The smelting is done in a rude way in furnaces built of adobes, yet it is stated that metallic tin can be produced at a cost of two cents per pound. The tin ore is found loose in the veins in irregular rounded masses, from minute sand-like particles, to pieces the size of a man's head. A curious form resembling small cylinders or stalactites is not uncommon.

Mr. Boyd estimates the number of veins known at six hundred, and the number of streams or arroyos yielding stream tin

at three hundred. This gentleman thinks that the tin ore is still forming. He assures me that work having been suspended on a mine in 1864, a portion of the vein was left standing. In 1870 he visited it again and found that new films or layers of cassiterite had formed, and in some places noticed that peculiar variety known as toad's-eye tin which he believes had formed during his absence.

These mines were discovered and worked on a small scale by the Spaniards from 1790 to 1824. From 1835 to 1846 they have been worked by Don Manuel Gracia, a native Mexican of Spanish descent, who amassed a fortune by extracting the tin and carrying it on mules to the city of Mexico, 590 miles distant.

Barranca is the name of a group of small veins rather than that of a single one. The vein in which the durangite is found is from four to six inches in thickness. It rises from a deep cañon, is nearly vertical, dipping but slightly. The fissure is filled with loose vein matter containing cassiterite in cylindrical pieces, quite small. Crystals of durangite occur singly with cassiterite in the white pulverulent matter before described. Beautiful crystals of a larger size and of a light orange color are sometimes met with attached to the walls of the vein. I have a few of these in my collection; they are quite different from those found in the vein matter. It was this variety which was first described by Prof. Brush.

The vein matter is described as being highly charged with arsenic. When thrown into the furnace, so abundant are the arsenical fumes evolved that the workmen cannot endure them, and a preliminary washing process is resorted to, by which a large proportion of the arsenical matter is removed. Sometimes in washing the vein matter, crystals of durangite are found, as are also those beautiful topaz crystals which have found their way to the cabinets of mineralogists in all parts of the world.

I understand Mr. Boyd to say that the crystals of durangite are only occasionally met with. The largest crystal known is now in my possession. It weighs 3·022 grams. Its greatest length is 19 millimeters and its extreme thickness 11 millimeters. The edges are sharp and all the angles well defined and perfect. There are some imperfections on some of the faces. It is of a beautiful orange-red color, resembling bichromate of potash.

The crystals found in the vein matter are usually small, and of a darker color. On weighing one hundred of them to ascertain the average, I found their combined weight to be only 7·750 grams.

San Francisco, 619 Montgomery St.

ART. XXXV.—*On the occurrence of Grahamite in the Huasteca, Mexico, and Notice of the Geology of that Region;* by JAMES P. KIMBALL, Lehigh University, Bethlehem, Pa.

THE descriptions of the albertite deposit of Hillsborough, New Brunswick, by Professor C. H. Hitchcock,* and of the grahamite deposit of the Ritchie Mine in West Virginia by Mr. W. M. Fontaine,† as well as by Mr. Henry Wurz,‡ show these deposits to widely differ from any known, or even possible, occurrence of mineral coal, from the nature of which albertite and grahamite have been shown by Wetherill, Wurz, and others, likewise to differ essentially. Both varieties occur in the state of Vera Cruz, Mexico, under such circumstances as to exhibit well the nature and proximate origin of such deposits.

A closer comparison of the two varieties, by means of a more extensive series of analyses than has yet been published, is required to fix the exact relationship between them. As distinguished by physical properties, they seem to pass into each other by insensible gradations, especially in the Ritchie deposit, and in such of the Mexican deposits as I have seen. Such analyses as are at hand, of specimens from one and the same deposit, indicate inconstant ratios in each variety—evidently depending on the degree of oxidation. This variableness shows that neither variety is a true mineral species, any more than other native hydrocarbon compounds, like petroleum, asphaltum, or mineral coals. The following observations serve to confirm the received theory of the nature and origin of albertite and grahamite, and to demonstrate that these bodies are essentially mineralized or fossilized asphaltums, derived from asphaltic petroleum, pittasphalt or maltha, by the loss of hydrogen and the addition of oxygen. In the degree of this alteration albertite seems to occupy a place between asphaltum and grahamite—the two varieties, however, constituting a single mineral type. The degree of oxidation of such compounds does not always correspond to the amount of retained or fixed oxygen—a large proportion of the increment of oxygen forming volatile compounds along with carbon and hydrogen, especially in the more advanced changes which result in their conversion to such anthracitic bodies, low in oxygen, as are often found in cavities of the rock in the older formations.

Numerous springs of asphaltic maltha, forming in places superficial deposits of solid asphaltum, occur on the eastern slope of the Cordilleras of Mexico, or rather, in the littoral zone

* This Journal, xxxix, 1865, 26–7.

† Ibid., vi, III, 1873, 409. ‡ Ibid., xlii, II, 1866, 420.

toward their base. A small lake fed by a spring of bitumen is reported to occur as far north as Galveston Bay in Texas within the Tertiary area.* More or less extensive sources of the same substance are common throughout the large area watered by the numerous streams discharging into the Tampico and Tuspan rivers, at whose mouths are the gulf ports of Tampico and Tuspan. A considerable quantity of chapapote, as it is called, is brought down by these streams, washed out to sea, and finally left upon the beach by the action of the waves. After such a thorough exposure to the elements, it loses its pitchy consistency, and becomes brittle and lustrous like jet. It has then a conchoidal fracture. In this condition it is sometimes gathered, and, though not extensively known, is highly esteemed as an article of export.

The northwestern portion of the state of Vera Cruz is known as the Huasteca, which may be described as the area south of the Panuco River, embracing the territory to the north of the plateau of Anahuac, watered by the three forks of the principal affluent of the Panuco—the Rio San Juan de Mexico—namely, the Capadero, the Amajaque and the Moctezuma. This section has received no attention from scientific travelers. In 1825, Burkhart, traveling from Tampico to Real del Monte, via Tantoyuca, passed along the upper Capadero. This river he mistook, however, under the name of the Rio Garzes, and supposed it to have an easterly, instead of a northerly, course, and to empty into the Laguna de Tamiagua. Saussure's map of the plateau of Anahuac represents this portion of Mexico with some approach to its geography, if not to its topography.†

Last April I made the journey from Tampico to Tempoal on the Capadero, crossing the Topila at Tanseme, and returned to the same port by way of Trinidad and Panuco. The topographical features of the country, which thus came under my observation, are not unlike what I have described to be the character of the eastern slope of the Cordilleras farther north as observed in Chihuahua.‡

The same succession of longitudinal valleys separated by parallel ridges is here seen, together with the same gradual acclivity toward the summit of the Sierra Madre, which in this latitude is about Zacatecas. The valleys, though broad, are, unlike the champlain valleys of Chihuahua, comparatively rugged, owing to the uneven erosion of the sedimentary rocks, which is caused by intrusions of trachyte. Their configuration is largely due to the successive changes of the beds of streams,

* Taylor, Statistics of Coal, p. 498.

† Coup d'œil sur l'hydrologie du Mexique, Geneva, 1862.

‡ This Journal, xlviii, 1869, p. 385,

caused by the gradual elevation, or periodic oscillations of level, of the Cordilleras during the Tertiary period and afterwards, and which phenomena, as I have elsewhere noted, are likewise strongly marked in northern Mexico.*

The area over which my route lay, is occupied by argillaceous sandstone, calcareous in places, whose foldings seem, generally speaking, to correspond with the present configuration of the surface, the whole of which, however, has been subjected to a very powerful erosion. One of the most remarkable evidences, both of the gradual character of the elevation of the Cordilleras in the lower latitudes, and of the fluvial character of their erosion, is to be seen in a widespread alluvium, composed of coarse gravel and heavy rolling stone in the valley of the Capadero, observed many miles away from the present channel of the river, wherever its heavy covering of fine silt-like alluvium has been washed away. Through these two superficial deposits successively the river has cut its present channel deep into a formation of soft shale beneath, locally known as *t-petate*, which overspreads the whole valley of the Capadero.

The shale is highly fossiliferous in places. Imperfectly indurated and weathering excessively, it causes the fossils to crumble. They include *Cardium*, *Arca*, *Ostrea*, *Corbula*, *Pecten*, *Caryatis*, *Serpula*, and a discoid, coiled and chambered rhizopod. With the exception of the last, all are too imperfectly preserved to admit of specific determination. Common to both the Cretaceous and Tertiary as these genera are, such specimens as I was able to extract fail to distinguish between these two periods. In a private report, written without access to my collection, the shales were referred to the Cretaceous upon the grounds of the apparent facies of these specimens. They prove however, upon examination, to be wanting in characteristic types, and too uncertain of specific identification to rest any conclusion of the kind upon them, especially as the stratigraphical relations of the shales themselves indicate, as I shall presently show, an unbroken and immediate sequence with alluvial Quaternary deposits. Arguing from the latter circumstance, it will be seen that they are more logically referred to the Tertiary. These shales are important as the seat of the grahamite deposits in the vicinity of Tempoal, and probably throughout the much larger region of the Huasteca, including, at least, the middle portion of the Capadero basin, or so much of it as lies between the Huejutla Mountains on the west and the Alacranes hills on the east. The region thus defined corresponds to the so-called "Coal-field of the Huasteca," the coal, however, as I judge from

* This Journal, xlviii, 1869, p. 381.

such specimens as I have seen, really being grahamite and other less thoroughly altered asphalts.*

Judging from a number of specimens of these outcrops from farther up the Capadero than the district visited by me, as well as from such facts as I could gather by inquiry, it seems most probable that the shales of Tempoal and of the Cristo Mine, which came under my observation at these and other points in the banks of the Capadero, extend, at least, some 60 miles farther up the river, as far as Chalma, so as to include the so-called coal deposits at the base of the Cochiscuatitlan hills mentioned by Antonio del Castillo, viz., Purisima, Providencia and Virginia. A specimen of grahamite, now in my possession, from Huautla, 50 to 60 miles still farther up the river, suggests a still greater extension of the same shales, found to be the seat of grahamite at Tempoal and elsewhere.

Except in the banks of the river, and the beds of branching arroyos, the grahamite-bearing shales nowhere come to the surface in the Capadero basin, within the range of my observation, although not far below the level of the valley-plain, or lower terrace of the river. Together with grahamite, they are reported, and may be readily believed, to outcrop in the Huejutla Mountains, as at the Venados, where a deposit of the former was described by the messenger sent thither for specimens, to be upward of two feet in thickness.

The shales are immediately covered by the above mentioned deposit of coarse rounded rubble, generally more or less cemented by selenite so as to form a conglomerate from 3 to 6 feet thick, and containing shells of *Paludina*. This is immediately overlaid by the heavy deposit of fine alluvium, the least thickness of which, as seen in the river banks, is some 60 feet. It overspreads the whole valley in the vicinity of Tempoal, as well as of the Aguacates, some 12 miles farther up the river.

In the vicinity of Tempoal, where alone my examinations have been special, the top of the shales is generally brought by undulations above low water mark—that is, above the level of the river in the dry season. Near the village, it rises some 30 feet above this level; at the Parajes, two miles below, some 25 feet; at the Aguacates, 12 miles above, some 60 feet; while at the Cristo Mine, it is near the water's edge, though rising directly on either side. We have as yet no data bearing on the thickness of the shale, as its edges are everywhere concealed—if not by overlying alluviums—by a detritus resulting from its own weathering, as it slacks at once on exposure to the air.

* Some attention of late, in the City of Mexico and elsewhere, has been turned to this region upon the strength of rather venturesome computations of the extent and value of the alleged coal deposits, based upon unexplored outcrops of what is assumed to be beds of bituminous coal. (*Compania Explotadora de Criaderos de Carbon de Piedra.* Mexico, 1876. A report by Antonio del Castillo.)

At Tempoal, at the Cristo Mine, and at the Aguacates—three out of five points where I have observed exposures of the shales in the banks of the Capadero, grahamite is found in greater or less quantity. Like many similar Tertiary sediments, the shales are in places quite gypsiferous.

Remnants of these Tertiary shales are to be seen in the banks of the Panuco at Puebla Vieja, near the mouth of that river. The same formation seems to answer to Burkhart's description of the formation occupying the Garzes, (Capadero) valley as high up as Chapula, and even still higher, as far as a little south of Pinolco, with occasional protrusions of the lower sandstone series—including beds of limestone, as between Huautla and Tlacolula, and again, south of Zagualtipan.*

According to this traveler, the clay shale of the valley about Chapula apparently overlies unconformably the limestone, which he believed to be the upper member of the sandstone series, forming the heights all the way from the coast, except where covered by trachyte. The mesa tops of the mountains just west of Chapula are of the latter volcanic rock, which likewise seems to form the summits along the whole range to the north. Approaching the volcanic plateau of Anahuac, the whole body of sedimentary rocks—together with overlying trachyte, was observed by Burkhart to decline to the south and to pass beneath the diorite and basalt of the table-land, which was geognostically mapped by Gerolt and Berghes in 1827.†

Mention is made by Sr. Castillo of the discovery of an "hexagonal" sigillarid as well as nummulitic forms in the so-called coal-bearing rocks of the Huasteca. The sandstone series, in whose depressions the Tertiary grahamite shales have been preserved from a sweeping denudation, has furnished a few fossils at Tampico, where it has been quarried. I succeeded, however, in finding none but fragmentary gasteropods, though perfect specimens of the same are said to be preserved in private collections there, which it has not been my privilege to see. So doubtful is the existence of true coal in the Huasteca, that the alleged discovery of palæozoic fossils, as claimed in Mexico by way of confirmatory evidence, as I infer, of the carboniferous age of the sandstone series—requires the support of other facts. It is proper to remark that in the interior of the country, the rock surfaces are absolutely unbroken, while covered with a tropical forest; hence the present impracticability of a successful search for fossils in this part of Mexico.

Burkhart also identified in the banks of the "Rio Grande" (Amajaque) the same formation of clay shale observed by him

* Aufenthalt und Reisen in Mexico in den Jahren 1825 bis 1834. Stuttgart, 1836. I, p. 53.

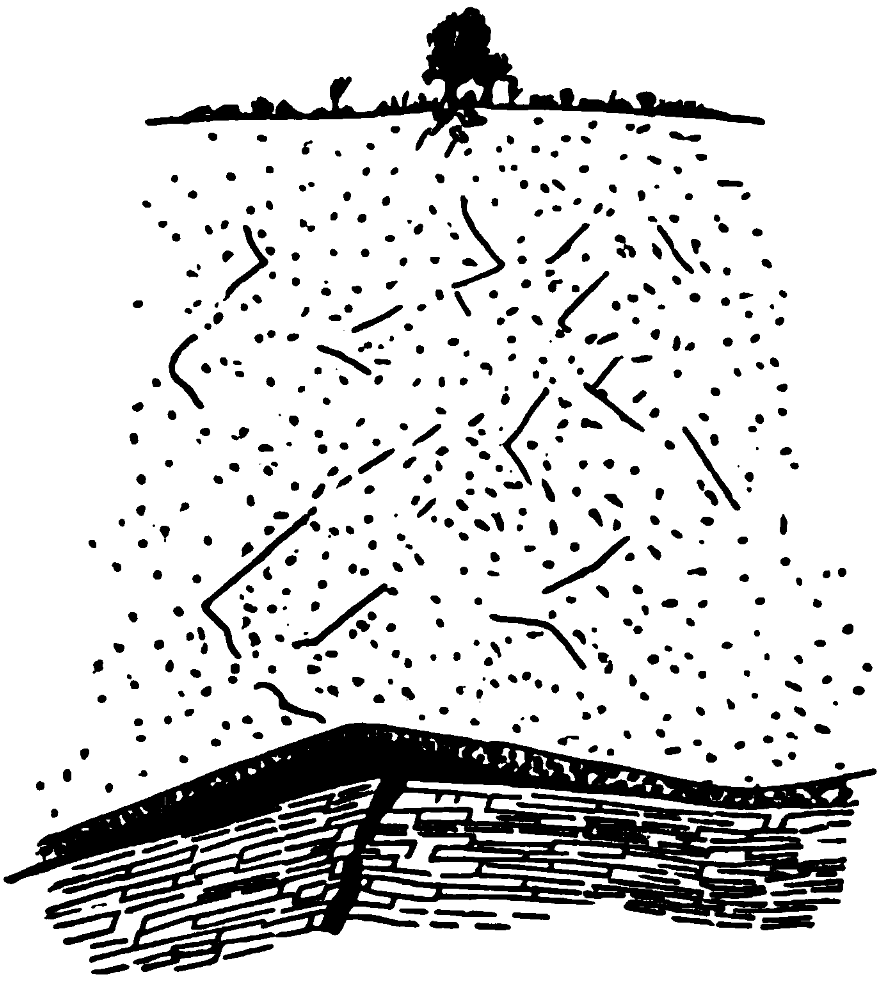
† Carta Geognostica de los principales Distritos Minerales del Estado de Mexico, 1827.

between Chapula and Pinolco in the Capadero basin, and thence inferred the geological identity of these neighboring basins.

I now proceed to describe the deposit of grahamite known as the Cristo mine.*

The original outcrop of the deposit appeared at the base of the west bank of the Capadero, on the Cristo Ranch, near the edge of the river at low water, and below the surface of the water during the rainy season. It appears to have been long observed, and to have been regarded by some persons as a deposit of bituminous coal, and by others as chapapote, but to have remained unexplored—perhaps through some discovery of its ill adaptation to the ordinary purposes of either fuels or asphalts. In 1873, the deposit was denounced as a coal-mining property.

The deposit consists of two continuous parts, the one occupying a nearly vertical fissure traversing the fossiliferous shales, and the other part conformably overlying these shales, which are slightly inclined. We have here the phenomena, first, of a deep-seated fissure transverse to the bedding of the formation, and filled out with grahamite; and, second, a nearly horizontal, and originally superficial, deposit of the same material overspreading the shale formation for a limited distance from the fissure. The latter occurrence is an overflow from the fissure, and, as it lies between the two formations, is to be referred to a period subsequent to the deposition of the shales, and before the conglomerate was spread upon them in the form of pebbly detritus. It thus happened when the shales formed the surface at this point, just as asphaltum is now commonly formed upon the surface, as a residuum from the evaporation and oxidation of liquid or pasty malthas, issuing from sluggish springs, or oozing from more extended sources, as from a certain stratum or rift in the rocks. Such phenomena, referable to the sandstone below, are to be seen beyond the boundaries of the shale formation in the neighborhood of the Cristo mine, and indeed are quite



* J. P. Kimball on a deposit of grahamite known as the Cristo Coal mine, with plate. 24 pp. 1876.

common in the surrounding portions of eastern Mexico, as already observed.

That portion of the overflow which originally appeared at the base of the river bank, has now been worked out, 210 tons having been quarried and shipped. So far as can now be ascertained, the overflow was altogether west of the fissure, which has a width, as far as developed, of 34 inches. The vein occupying the fissure has a columnar structure transverse to its sides, and shrinkage partings, or joints, parallel to its sides. It has thus far proved remarkably homogeneous in structure, and free from admixture of rock or clay. Its dip is 64° to the W. Near the point where it passes out of sight under the river bed, it is joined, at an acute angle, by a narrower and tapering vein of which the maximum width is 9 inches. According to those who have had charge of operations at the Cristo mine, the deposit, including both vein and overflow, was excavated within a dam to a depth of ten feet, and, at the same place, measured fifteen feet across. The vein proved of the same width as observed by me nearer the bank—that is, thirty-four inches. This point, now under water, was stated to be 120 feet from the base of the latter. Another small branch is partially seen on the opposite side.

The shape of the overflow is indicated as near as is now practicable, by the excavation outside of the bank and by the work underground. The latter consists of a timbered shaft, 72 feet deep, sunk from the top of the river bank or terrace, 196 feet from the edge. From the bottom two levels have been run out at right angles, one 19½ feet long toward the river (east), and the other 27½ feet long toward the north. These workings are in that portion of the deposit which for convenience I call the overflow. Its greatest thickness is developed in the east level, at the end of which it measures 6½ feet and dips 19½° S. W. At the end of the north level it has a thickness of but 15 inches, and a dip of 20° to the northeast. In the shaft the thickness of the deposit falls from 34 inches at the southeast corner, to 15½ inches at the opposite N. W. corner, to 20 inches at the S. E. corner, and to 15 inches at the N. E. corner. It therefore appears that the overflow of the vein has a limited spread underground, the same as it proved outside the bank at the water's edge. Its thickest portion is in the direction of the river, and continuous, I think, with the thickest part of the original outcrop; that is, the portion nearest the fissure, which was undoubtedly its source, and from which it sloped with the configuration of the surface at the time, and thinned away toward its edges. The fissure occupies the axis of a gentle anticlinal with a dip of 14° W. on the W. side, and of 4° E. on the opposite side. As the overflow conforms to the steeper dip,

it appears that the fissure must have been made at the time of the elevation of the shales, and soon afterwards filled with asphaltum, which continued to form after it had been filled. That no great period was required for this operation, is shown by the fact that the overlying conglomerate also conforms to the stratification of the shales as well as to the outline of the overflow of the grahamite, locally intervening.

The occurrence of such a fissure in shales so imperfectly hardened, and so easily weathered, affords another proof that the filling of the fissure immediately followed its formation, that is, after the emergence of the shales and before the deposition of the overlying alluvium. It is from this evidence of the direct sequence of terranes, and the relation thus established with subsequent alluviums that, in the failure of the evidence of their fossils, I refer to the Tertiary the grahamite-bearing shales of the Capadero basin. These are probably remnants of the littoral Tertiaries of eastern Mexico and Texas.*

The strike of the fissure is nearly north and south, directly across the river. No attempts have been made to trace it beyond the excavation near the water's edge, its character as a fissure not having been recognized previous to my visit. A length of about 300 feet upon it had at that time been developed.

The sandstone formation is the source of a number of deposits of chapapote or asphaltum. Numerous deposits are said to occur north of the Panuco River. One deposit, which I visited, is found on the Tanelul Ranch, occupying an elevated basin or cul-de-sac between two hills of the Alacranes range, here forming the boundary of the Capadero valley. The point is some 2½ leagues east of the Cristo mine, and *directly in range with the course of the Cristo fissure as far as traced.* The chapapote has accumulated from the evaporation of liquid maltha, which now issues in the form of a sluggish spring with a number of orifices. Here may be witnessed the same process by which the above described overflow of the Cristo mine was originally formed. The source of the chapapote spring is the sandstone above mentioned, on which rest the grahamite-bearing shales of the valley below. It thus appears that the uplifted portions of the underlying sandstone are at present the source of chapapote springs depositing that mineral substance upon the surface. Ancient, and perhaps more copious, springs of the same kind issued from the depressed portions of this formation, and forced their liquid maltha into the fissures and lesser interstices of the overlying shale, which, as I have already stated, is remarkably cleavable and imperfectly indurated. The tendency of such a body of shale or shaly clay, exceedingly fine in texture, to form

* Archiv de la Commission Sc. du Mexique, ii, p. 124.

shrinkage and cleavage partings is well known. Hence this formation, from its nature otherwise impervious, became the permanent receptacle of maltha or asphaltic petroleum, issuing from the sandstone below; and probably the more freely under a hydrostatic pressure, in which water played a part, and the action of which is strikingly suggested by the configuration here observed of a stratigraphical basin bordered by elevated plateaus. The inspissation of maltha or pittasphalt, and even petroleum, to grahamite and other mineral bitumens, by the loss of hydrogen and the addition of oxygen, is a well known occurrence which may be artificially illustrated in the laboratory.* While asphaltum is observed to be the product of the immediate evaporation and oxidation of maltha at or near the surface, a slower and continued oxidation beneath the surface —in fissures, cavities and interstices of the rocks—has produced grahamite, albertite and other less hydrogenous hydrocarbons of the same type.

The smaller exhibitions of grahamite in the shale of the river banks, at Tempoal and the Aguacates, are of the same general nature as the deposit of the Cristo mine. They occupy interstices between divisional planes of the formation, thus forming veinlets which often pass from between one kind of partings to another. Hence even the larger of these deposits or pockets are very capricious in position, while the smaller ones merely reticulate the rock. They seem to have no connection or channels. The question is thus suggested, whether this formation, in places densely filled with organic remains, has not, in part at least, been the primary source of the hydrocarbons which it contains, as well as those of the underlying sandstone, from which, since its emergence, it has been for the most part denuded. This theoretical question must remain open until the relations of the numerous deposits of chapapote in eastern Mexico to the rocks from which they spring, shall be observed and compared. The above small and scattered deposits of grahamite have no economic value—although fine hand specimens can be taken from any of them.

Unlike the New Brunswick variety, which is compact in structure, conchoidal in fracture, and of a resinous and brilliant luster, the Ritchie and Cristo varieties, which are very similar, are of rather granular consistency. They possess a very distinct cleavage, a jointed structure, as well as columnar partings in the deposits, somewhat irregular, on account of the varying conditions of these deposits themselves. The Cristo mineral is more uniformly lustrous than that from Ritchie County, and of a greater coherence, though none the less distinctly cleaved and jointed.

* W. P. Jenny, Am. Chem., v, p. 10.

Both varieties are found at the Aguacates in veinlets. Some of these are filled with a conchoidal variety, like that from the Albert mine, while others consist of the same columnar and sub-conchoidal material as that from the Cristo mine. The conchoidal fracture in both differs simply as to degree, varying with the degree of brittleness.

A few barrels of the mineral from the Cristo mine having been sent last autumn to Glasgow, an analysis and technical examination of the sample were made by Mr. William Wallace, of that city.

ANALYSIS OF CRISTO-GRAHAMITE.

Specific gravity.................1·156.

Volatile matter	Illuminating gas........	61·32	62·14
	Sulphur	·46	
	Water	·36	
Coke....................	Fixed Carbon	31·63	37·86
	Sulphur	·37	
	Ash..................	5·86	
			100·00

ANALYSIS OF COKE.

Carbon..	83·56
Sulphur	·98
Ash..	15·48
	100·00

ART. XXXVI.—*On a "Geological Chart of the United States east of the Rocky Mountains, and of Canada;"* by FRANK H. BRADLEY.

IN publishing a new compilation of the general results of geological surveys of the eastern United States and Canada, the writer has felt under obligation to state the reasons for the adoption of any peculiar features of the chart, and also desirous of noting some theoretical points to which this revision of data has called attention.

Mercator's projection was adopted, in order to show most accurately the general trends of the outcrops. The consequent distortion prevented the use of the ordinary mileage scales; but the average scales, for every two degrees, are inserted along the left-hand border.

The scale used is so small that it was impossible to indicate either the very *small* areas of the different formations, or the slighter irregularities of outlines. While this renders the chart inaccurate as regards detail, it has the compensating advantage

of representing with more uniform accuracy areas which have been surveyed with more and with less minuteness.

Considerable portions of the metamorphic areas heretofore mapped as Archæan have recently been proved to be Silurian. These discoveries have cast so much doubt upon the true age of much of the remainder, that I have, in several cases, been unwilling to follow authority in calling it Archæan. The work done in New England by Prof. Dana, and in the Southern States by the writer, has already reduced the Archæan area of the Appalachians by nearly one-half, and has given data for comparison with series of rocks previously described from Virginia, Pennsylvania and New Jersey, which justify the inference that large portions of the metamorphics of these states will also prove to be Silurian. Following this inference, the areas of this region, previously considered Archæan, have been considerably reduced. Much of the uncolored portion of New England is undoubtedly Silurian and Devonian, but with limits which cannot now be determined. Prof. Verrill refers to the Archæan, with much certainty, the belt of red granites running from Mount Desert to the Bay of Chaleur. The Archæan area of northern New York should probably be slightly reduced;* but the age of the principal part of it seems pretty well determined.

The typical Huronian of Canada, according to description, occupies the position, and presents the lithological characters, which we should naturally expect for the metamorphic portion of the adjoining Lower Silurian, corresponding precisely, in both respects, with extensive beds of that age in the Appalachians. I have accordingly colored them as Lower Silurian. After reaching that conclusion, I learned, through Prof. Selwyn, that Sir William E. Logan held the same view for some time before his death, though it is not, I believe, shared by Prof. Selwyn and his colleagues of the Canada Survey. Prof. Selwyn also informs me that recent work of the Survey has shown a continuation of the Huronian belt north of Lake Huron to beyond Lake Mistassini, with a width of over three hundred miles at one point. Considerable portions of the so-called Archæan area of Wisconsin and Michigan have been shown by Brooks and Pumpelly and others, to be the equivalent of the Canada Huronian, for which reason they might with probability be referred to the Silurian; but the data yet published have seemed so incomplete, that the writer has preferred to leave the area uncolored. Both this and the metamorphic area of Minnesota, as yet unexplored, doubtless include some genuine Archæan.

The metamorphics of Missouri are probably Archæan, and are so colored. Those of Arkansas and part of those of Texas

* Brooks, this Journal, III, iv, 22.

are probably Silurian, but not certainly; those of the Indian Territory have, as yet, yielded no data for a conclusion; all these are therefore uncolored.

Sherwood's results, as published by Hall, will require some changes along the north line of Pennsylvania, in future editions: the data did not reach me until this edition had been struck off.

It has long been held that the Appalachian and the Kentucky-Illinois coal-fields were formed in entirely independent basins, having no communication with each other, and consequently no probable equivalency of coal-seams. A glance at the map, showing the close proximity of the two fields in southern Kentucky, must give anyone strong suspicions that this view is incorrect for that part of the country; and examinations of the two opposing escarpments would strongly confirm the suspicions, though we must probably admit the partial division further north, by the Cincinnati anticlinal. In northern Tennessee, the western face of the Cumberland plateau shows the bold outcrop of about a thousand feet of the coal series in regular horizontal position, with no signs of any abrupt thinning out, as thus far observed. Less than sixty miles, across a continuous outcrop of practically horizontal Subcarboniferous strata, brings us to the eastern escarpment of the western field, where the coal-measures are somewhat thinner, at a slighly lower level, and with a less abrupt outcrop, but still undisturbed and evidently only the continuation of beds which once covered the intervening area. I have long taught this continuity of the two fields; and I understand that Prof. Safford holds the same view, while Dr. Newberry, in conversation, strongly opposes it. How far the union continued southward seems difficult of determination. Judging from the broad western extension of the Coal-measures through Alabama, and of the horizontal Subcarboniferous through Tennessee, to the eastern line of what appears to have been a pre-Cretaceous Mississippi valley, together with the great eastern extension of Coal-measures in Arkansas, to the western margin of the same valley, I am inclined to infer a former continuity of the series across the intervening space of 225 miles, and indeed, over the whole area of lower strata in Tennessee, Arkansas and Missouri, with the possible exception of a few islands, such as Newberry suggests for the Nashville basin, (Ohio Geology, i, 96–110). If the Coal-measures were thus continuous, the erosion of the Mississippi valley must probably be referred to the same age (Jurassic?) as that of the Triassic beds on the Atlantic slope, mentioned below.

Wells, dug through the drift of northwestern Indiana,* have yielded considerable masses of Devonian black shale, hardly displaced from contact with the underlying limestone, in such abundance as to lead to the belief that this bed was for-

* Dr. R. T. Brown, 1869, letter to the writer.

merly continuous across much of the area which, from the known outcrops, we are obliged to color as mainly Upper Silurian. Indeed, it suggests the probability that the Michigan coal-field may once have been continuous with that of Indiana and Illinois; but the surface of that region is so flat and so deeply covered with drift, that it would hardly be *possible* to obtain the data for a *certain* solution of the problem.

Noticing my own neglect of such points, I am led to ask geologists, generally:—Have we paid sufficient attention to the indications of former *probable* extensions of formations over areas where no portions of them now remain?—a point of little practical importance, perhaps, but certainly of great theoretical interest.

I regret that the scale of the map forbids the representation of the numerous trap dikes, probably of Triassic age, which cut across the metamorphics of North Carolina, South Carolina, Georgia and Alabama. The dips of the sandstones and shales in the two Triassic areas of North Carolina give pretty strong evidence of these being only the border-remnants of a huge ge-anticlinal, over a hundred miles wide,* (the connecting arch being now removed,) which probably extended far to the southwestward, and possibly over much or all of the area intersected by the trap dikes. Kerr's estimates show the erosionof from 10,000 to 25,000 feet of strata, along the back of the fold; and fully as much must be allowed for, between the New Jersey and Connecticut River areas of Triassic if we accept the opposing dips of these as evidence of another, or part of the same, great ge-anticlinal. There are, it is true, strong objections to this view for the latter region; but no other theory seems to the writer so well fitted to meet the facts.

We have, as yet, no certain evidence of distinctively Jurassic strata on the Atlantic slope of this continent; was then the Jurassic the period during which this enormous folding, eruption (and erosion, in part, at least) took place? For the following Cretaceous has apparently been but very slightly displaced, if at all, except by the pretty uniform secular movements of the continental mass. It may also be questioned whether the Permian period, equally destitute of distinctive deposits along the Atlantic border, was not the era of the upheaval and metamorphism of the Appalachians, which was plainly post-Carboniferous and pre-Triassic.

It seems impossible to indicate fairly the Quaternary beds of the continent upon the same chart with the other formations; since, in one form or another, they cover pretty much the whole surface of the country. The marine beds of the period are too small to be of any importance on a chart of this scale: the river- and lake-border formations are sufficiently well *located*

* Kerr, Geology of North Carolina, i, 141–6, 1875.

by the modern lakes and streams themselves; while, if represented, these and the beds of drift would, over much the larger part of the country, leave exposed only the narrow isolated outcrops of the earlier formations which the learner finds it so difficult to correlate, in his mind's eye, and would show next to nothing of the general structure which it is the main purpose of such a chart to exhibit. Still, charts of the Quaternary continent would be exceedingly instructive, in their exhibition of the old lake-basins and drainage-lines of the continent. Besides the present Great Lakes, with their much greater extent and direct southern outlets, there were at least three great Quaternary lakes, in the Mississippi basin. One has its boundaries well marked by the Lower Silurian outlines of the Nashville basin of Middle Tennessee, its walls being mostly Subcarboniferous. Another occupied the western part of the Silurian basin of Central Kentucky and Southern Indiana, having similar walls on the west, (where its bordering sand-banks lie near the tops of the "Knobs"* fully 400 feet above the Ohio at Louisville,) and stretching far up the slopes of the Cincinnati anticlinal on the east—the boundaries in this direction being as yet unreported. A third occupied a large area on the flats of the Upper Silurian and Devonian areas of Northwestern Indiana;† and perhaps still others swept over the broad prairies of Illinois and the States further west.

Dana has long since called attention to the now-submerged old valley of the Hudson, as marked on the continental border, out to the true edge of the oceanic depression. The lines of soundings along the coast, kindly furnished to me by the officers of the Coast Survey, originally showed a slight bend opposite the mouth of Chesapeake Bay, probably indicating a corresponding notch in the bottom-slopes; but this was overlooked by both the engraver and the proof-reader. In the Gulf of Mexico, the angles of the soundings-lines point directly to Pensacola, the deepest harbor of the Gulf; and this line, continued, meets the Tallapoosa River at its abrupt angle near Montgomery. I have been informed (by Prof. Nicholson, of Knoxville, Tenn., I think) that a broad valley, with high terraces, but now deserted by the river, runs directly south from this angle of the Tallapoosa, as if on a direct course for Pensacola. During the Champlain period, when the streams of all this region were from 170 to 200 feet or more above their present level, this Tallapoosa river received a large share of the drainage of East Tennessee and Western North Carolina; and I have suspected that this old channel was the line of outflow of this great flood, direct to the deep water of the Gulf. The Gulf of Maine and the Gulf of St. Lawrence are well marked by the

* Borden, Geological Survey of Indiana for 1873, p. 181.
† Geology of Illinois, iv, 227.

fathom-lines.* The drift of icebergs, as marked by dots on the small corner-map, shows the source of the material of the "banks" of Newfoundland, and the area over which the growth of the continent is now most actively going forward. It is also evident that the shallowness of the Strait of Belle Isle, which prevents the passage of any but the smallest icebergs, is the principal means of preventing the filling up of the deep channel of the Gulf of St. Lawrence with the sediment now dropped on the "banks."

I shall be under deep obligations to all who will be so kind as to furnish exact data for corrections to be made in future editions of the chart.

ART. XXXVII.—*Observations upon the latest Planetoids;* by C. H. F. PETERS. [From a letter to one of the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Sept. 5, 1876.]

As the moonlight now for some days is interfering with observing the small planets, I communicate of the observations hitherto obtained the first and last positions of each, omitting for brevity's sake the intermediate ones. The dates of discovery and the names proposed of these new additions to the group are the following:

(165) *Loreley*, 10·7 magnitude, discovered Aug. 9.
(166) *Rhodope*, 11·2 magnitude, discovered Aug. 15.
(167) *Urda*, 12 magnitude, discovered Aug. 28.

1. Observations of *Loreley:*

1876.	Mean time.	α	δ	
	h m s	h m s	° ′ ″	
Aug. 9.	10 34 27	21 27 46·57	−10 0 10·7	(16 comp.)
Aug. 27.	10 26 49	21 13 2·52	−10 13 8·5	(10)

besides observations of Aug. 10, 11, 12, 13, 17, 20, 21, 23.

2. Observations of *Rhodope:*

1876.	Mean time.	α	δ	
	h m s	h m s	° ′ ″	
Aug. 16.	12 27 2	21 31 24·30	−19 15 16.1	(14)
Aug. 28.	11 33 39	21 21 55·06	−21 7 20·0	(10)

besides Aug. 17, 20, 21.

3. Observations of *Urda:*

1876.	Mean time.	α	δ	
	h m s	h m s	° ′ ″	
Aug. 28.	14 18 21	21 58 32·28	−11 33 41·4	(12)
Aug. 30.	13 35 16	21 57 1·33	−11 23 29·5	(12)

* On the map, by the mistake of the engraver, the 50-fathom line, along the west side of the Gulf of St. Lawrence, is made just like the 100-fathom line.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Estimation of Nitrogen in Potable Waters.*—Frankland, in a paper on the analysis of potable waters, gives the results of eight additional years of experience with the waters supplied to London. He says that the two chief objects to be kept in view are "the discovery of the evidence of *past* pollution by organic matter and the quantitative determination of *present* or actual organic impurity." With reference to the first point, he gives his opinion that the presence of nitrogen in the forms of nitrates, nitrites and ammonia in potable waters, in quantity above that which can be derived from rain, is reasonably safe and trustworthy evidence of the previous pollution of that water by animal matters. As to the second, he shows that, of the four processes proposed for determining organic constituents, known as the ignition, the permanganate, the albuminoid-ammonia and the combustion methods, the two first are quite useless; of the third he concludes from the extended experiments made by himself and others: 1st, that it affords no evidence whatever of the absolute quantity, either of organic matter or of organic nitrogen, present in potable water; 2d, that it does not indicate, even approximately, the relative quantities either of organic matter or of organic nitrogen in different samples of such water; 3d, that it affords no indication either of the presence or of the proportion of albuminoid as distinguished from other nitrogenous organic compounds; and 4th, that it is entirely useless therefore in the examination of waters for sanitary purposes. The combustion process, however, devised by himself nine years ago, he believes to be reliable. He claims for it: 1st, that it is the only method at present known which affords any trustworthy information respecting the organic matters present in potable waters; 2d, that it is the only method which even professes to determine organic carbon in such waters; 3d, that the determinations by it of organic carbon and nitrogen are fairly accurate, notwithstanding the very minute quantities of matters dealt with; and that the errors, even of a comparatively inexperienced analyst are far within the limits which would affect a verdict upon the quality of the water submitted to investigation; 4th, that it is the only process which discloses the proportion of nitrogen to carbon in the organic matter of waters, such information being often of prime importance in reference to the origin of the organic matter; and 5th, that since the modifications which have been made in the mode of evaporation the process can now be conducted in any laboratory and with a moderate expenditure of time and labor.—*J. Ch. Soc.*, clxii, 825, June, 1876.

G. F. B.

2. *On the Absorption of Nitrogen by Organic substances.*—Berthelot has found that pure nitrogen gas is absorbed by or-

ganic bodies at the ordinary temperature, under the influence of the silent electric discharge. Benzene, for example, absorbed, for every gram used, four or five cubic centimeters of nitrogen; the benzene being exposed either in vapor or in very thin layers of liquid. A condensed, polymerized compound resembling a resin, collected on the sides of the tube, which evolved ammonia when heated. Turpentine, marsh gas and acetylene act similarly. Filter paper slightly moistened, absorbs notable quantities of nitrogen, when thus treated, which is set free as ammonia on combustion with soda-lime. The same fact was observed with dextrin. Since neither nitrates or nitrites nor ammonia is produced, the author believes that a complex nitrogenous compound is formed by the direct union of the free nitrogen with the substance employed. He considered these facts of importance relative to the fixation of atmospheric nitrogen in nature.—*Bull. Soc. Ch.*, II, xxvi, 58, July, 1876. G. F. B.

3. *Action of the Copper-zinc Couple on Chlorates and Perchlorates.*—Eccles, working under Thorpe's direction, finds that potassium chlorate is easily and completely reduced to chloride by the action upon its solution at the boiling temperature, of a properly made zinc-copper couple; so that an accurate quantitative method may be based on it. Potassium perchlorate, however, undergoes no change under these conditions. This fact the author has made excellent use of, to prove that the decomposition of the chlorate by heat takes place in two stages, in the first of which perchlorate is produced. The progress of the decomposition may also be accurately studied in this way. No perchlorate is formed, however, if manganese dioxide be added to the chlorate.—*J. Ch. Soc.*, clxii, 856, June, 1876. G. F. B.

4. *On a supposed shifting of Atoms.*—Demole has examined critically the substance obtained by Baumstark by the action of an alcoholic solution of iodine upon ethylene, to which he assigned the formula C_4H_9IO, and which he supposed to be ethylidene-iod-ethylin. The improbability of the ethylene grouping being changed to that of ethylidene by this simple action, led Demole to prepare the ethylene compound synthetically with a view to compare its properties with those of the new body. For this purpose, mono-ethyl-glycol was prepared, and treated with phosphorus iodide. The reaction is:

$$\left(\begin{cases} CH_2OH \\ CH_2OC_2H_5 \end{cases}\right)_3 + PI_3 = \left(\begin{cases} CH_2I \\ CH_2OC_2H_5 \end{cases}\right)_3 + P(OH)_3.$$

The substance thus obtained was found to be identical in its properties with that obtained by Baumstark. His body is, therefore, ethylene-iod-ethylin. By the action of sodium-ethylate on it, acetal is produced.—*Ber. Berl. Chem. Ges.*, ix, 743, June, 1876. G. F. B.

5. *On Crystallized Glycerin.*—Van Hamel Roos has examined a quantity of fifty-six pounds of crystallized glycerin. The crystals are monoclinic, perfectly colorless, and of a pure sweet taste.

Placed in ordinary good glycerin, they cause the formation in it of magnificent crystals. When melted at 60° F. the liquid has a specific gravity of 1·261. This cooled to 30° F. solidifies easily by the introduction of a small crystal of glycerin. At 24° F., the solidification is spontaneous after some time, though agitation seems to be indispensable. The melted glycerin is much less easily fermented, and hydrocyanic acid is without action upon it. Since the crystallization of glycerin depends on its being pure and anhydrous, the formation of crystals is the best test of purity, and at the same time the best method of purification.—*J. Chem. Soc.*, clxi, 651, May, 1876. G. F. B.

6. *On the Lactic acid obtained from Inosite.*—Scheerer, the discoverer of inosite, mentions its breaking up by fermentation into lactic acid. VOHL, the discoverer of phaseomannite, which he subsequently proved to be identical with inosite, also proved the identity of the lactic acid from this substance, with the ordinary lactic acid of fermentation. This statement having been called in question by Hilger, Vohl fermented 250 grams inosite dissolved in two liters of water, by the aid of putrid cheese with the addition of chalk, at a temperature of 25° to 28° R. The thick mass of calcium lactate was treated with animal charcoal, boiled and filtered hot. On cooling, calcium lactate crystallized out and was purified by repeated crystallization. These crystals had 29·098 per cent crystal water; the salt of common lactic acid contains 29·221, that of sarcolactic acid 21·721. The zinc salt gave 18·104 per cent water, the quantities of the two salts respectively being 18·178 and 12·901. Moreover, the insolubility of the zinc salt showed it to be common lactate. Oxidation yielded acetic and formic but not a trace of malonic acid.—*Ber. Berl. Chem. Ges.*, ix, 984, July, 1876. G. F. B.

7. *Synthesis of Polybasic Acids by the action of Carbon dioxide on Salicylic acid.*—OST finds that by passing a stream of dry carbon dioxide gas over basic sodium salicylate, the gas is absorbed and an acid formed having the formula $C_6\begin{matrix}H_3\,COOH\\OH\,COOH\end{matrix}$ which he calls ortho-phenol-dicarbonic acid. A similar tricarbonic acid is also formed in this way.—*J. pr. Ch.*, II, xiv, 93, July, 1876. G. F. B.

8. *Freezing of Colloids.*—Prof. GUTHRIE described to the London Physical Society some experiments on the freezing of aqueous solutions of colloid substances, which he has been studying in connection with his recent investigation on cryohydrates, etc. If a solution of sugar be gradually cooled, the temperature at which ice separates out is always below 0° C. and the extent below increases with the amount of sugar in solution; but he finds that in a solution of gum having exactly the same chemical formula, the ice always separates at 0° C. whatever be the amount of gum present. Thus while every crystalline substance forms a freezing mixture when mixed with ice or snow, colloids are incapable of doing so. The gum and the water do not recognize each other;

and similar results were obtained in the case of gelatine and albumen. These facts are strictly in accordance with the results of Prof. Graham's classical researches. It also follows that, when heated, similar effects are observed, and Prof. Guthrie has found that solutions of gum in varying proportions always boil at 100° C. —*Nature*, xiv, 264. E. C. P.

9. *Explosion of Fire Damp.*—M. MALLARD has measured the velocity of inflammation of various mixtures of fire-damp and air. Various mixtures were set in motion with different velocities, and that velocity at which the zone of combustion remained stationary measured the velocity sought. The highest velocity of inflammation was 560 meters per second, and it occurred in a mixture of 0·108 vol. of fire-damp in one volume of the mixture. On increasing or diminishing the proportion of fire-damp, the velocity in question diminished very rapidly, becoming *nil* with a proportion of ·077 vol. on the one hand, and 0·165 vol. on the other, below which the mixtures are neither explosive or inflammable. It is notable that a variation of even 0·01 in the proportion of fire-damp is sufficient to convert an absolutely indifferent mixture into a highly dangerous one.—*Naturforscher*, Feb., 1876; *Nature*, xiv, 202. E. C. P.

10. *Velocity of Electricity.*—Dr. W. SIEMENS has measured the velocity of propagation of electricity in land telegraph lines by the following apparatus: two condensers have their outer terminals connected by a metallic wire. Their inner terminals are attached to two points placed near a registering cylinder connected with the earth. The connection for one point is a short wire, and for the other a telegraph line. The two condensers are discharged simultaneously by connecting their outer terminals with the earth when the cylinder gives the interval which has elapsed between the two sparks. Instead of the telegraph line a rubber tube thirty meters long and twenty millimeters in diameter and filled with sulphate of zinc was first used. The interval between the discharges was inappreciable, and certainly did not exceed five millionths of a second. With a line 25·36 kms. long, the retardation was 125-millionths; with another of 23·37 kms. the retardation was 101-millionths, and with a third of 7·35 kms., thirty millionths. These times are nearly proportional to the length of the lines. The capacity of the two shorter lines was ·15 and ·063 microfarads and their resistance eight Siemens per kilometer. The retardation by comparison with that of condensers of known capacity ought to be only two millionths of a second. Thus the retardation observed is much greater than that required to charge the cable and is not proportional to the square of the length. M. Siemens concluded from this that the electricity has really a velocity of propagation. It must be remarked, however, that the insulation of the lines was not observed, and that slight leakages through the supports would have the effect of increasing the time necessary to charge the line, and of rendering it more nearly proportional to the length.—*Pogg. Ann.*, clvii, 309; *Journ. de Phys.*, v, 228. E. C. P.

11. *Polarization Currents.*—MM. SCHILLER AND CALLEY describe an experiment showing the electro-dynamic action of a polarization current. It is well known that water cannot be decomposed by a single Daniell's cell; but if a voltameter and galvanometer are inserted in the circuit of such a cell the needle deviates at the moment of making or breaking the circuit. These well known facts have led some persons to compare a voltameter to a condenser of great capacity. The question is to determine whether the liquid conductor can exercise an electro-dynamic action while the electrodes are being charged. *A priori*, this is not self-evident, but is established by the following experiment. In a Wiedemann's galvanometer, one of the bobbins was replaced by a coil formed of a rubber tube filled with water free from air and slightly acidulated. The coil consisted of thirteen turns six centimeters in diameter. The resistance was 1600 Siemens. The two bobbins (one metallic, the other liquid) were so placed that the current of four Daniell cells traversing both at the same time and decomposing water did not deviate the needle. The four cells were then replaced by a single one. On closing the circuit no deviation was observed but on removing the metallic bobbin a deflection was obtained amounting in the first swing to twenty divisions.—*Journ. de Phys.*, v, 261. E. C. P.

12. *Magnetic Induction.*—M. CHWOLSON presents a second valuable memoir on the mechanism of magnetic induction, which process he seeks to explain by the supposed existence of molecular magnets which are turned by the external force in one direction. In his former paper he dealt with the case of temporary induction in soft iron; he here treats of magnetic induction in steel. The paper is in five chapters; in the first are summarized the results obtained by previous observers, those of Jamin being given with special fulness. In the second the author describes his experiments, which require a modification of Jamin's theory. Of Jamin's two laws relating to the action of positive and negative currents or permanently magnetized bars, Mr. Chwolson finds the first absolutely correct; the second incorrect. Jamin's mistake he considers to be in the supposition that the negative current acts only on the surface layers, leaving those below untouched; it is shown on the contrary, that the least negative current acts on all the layers and diminishes their intensity. Then he gives a mathematical theory of induction in steel; supposed the first attempt of the kind (if Maxwell's but partly successful one be excepted). In the fourth chapter he explains, on the basis of theory, the various experimental results got by different observers; and in the fifth shows how certain results that might, *à priori*, be foreseen from the theory, have been verified.—*Pogg. Ann. Erganz.*, vii, 4; *Nature*, xiv, 202. E. C. P.

13. *Constants of Nature.* Parts II and III, and first supplement to Part I. Compiled by F. W. CLARK, Prof. of Chem. Univ. Cincinnati. 1876. Washington. Smithsonian Misc. Collections, Nos. 276, 287, 288. Part II of Prof. Clark's thorough and very

useful work, includes a table of specific heats for solids and liquids; Part III, tables of expansion by heat for solids and liquids; and the Supplement to Part I, specific gravities, boiling points, and melting points.

II. Geology and Mineralogy.

1. *On the Age of the Vertebrate Fauna of the Eocene of New Mexico;* by Prof. Cope. (Proc. Acad. Nat. Sci. Philad. for April, 1876.)—Comparison with the established scale of geological horizons of Europe has established the fact that the beds in question belong to the Eocene category, as I have already shown* to be true of the longer-known Bridger beds of Wyoming. It remains to collate them with the numerous subdivisions of that period. The differences between the Wahsatch and Bridger faunæ have been in part pointed out in my Report on the Vertebrate Fossils of New Mexico,† 1874, and may be more fully stated as follows:

(1) Divisions found in the Wahsatch beds not yet reported from the Bridger beds. Aves, genus *Diatryma* (allied to *Gastornis*); mammalia, *Tæniodonta; Phenacodus; Coryphodon;*‡ *Meniscotherium;* most species of *Hyracotherium.*

(2) Divisions found in the Bridger beds not yet found in the Wahsatch: fishes, *Amiidæ;* reptiles, *Ophidia; Anostira;* mammals, *Mesonychiidæ; Tillodontia; Achænodon; Dinocerata; Palæosyops;* most species of *Hyrachyus.*

The Wahsatch horizon of Wyoming has not yielded so many species of vertebrata as those of New Mexico,§ but the close resemblance of the two faunæ may be observed in the following list of forms which I obtained at several localities: Fishes, *Siluroids;* mammals, *Hyracotherium*, two species; *Phenacodus; Coryphodon*, two to three species. As is well known, the Wahsatch beds underlie those of the Bridger group, and we therefore look for their European equivalent in the lower part of the series. It has been already pointed out ‖ that the absence of *Hyopotamus* and *Anoplotherium*, and allied genera, from the Bridger horizon, precludes an identification with the Upper Eocene of Europe. The comparison of the Wahsatch fauna with that of the lowest of the three divisions into which Professor Gervais has arranged the European Eocene, shows a remarkably close correspondence. This epoch, the Suessonien of D'Orbigny (Orthrocene, Gervais), includes the marls of Rilly and lignites of Soissons, the Thanet sands, London clays, etc. Fossils from these beds appear to have been no better preserved than those of the Wahsatch beds of the Rocky

* Proceedings American Philosophical Society, 1872, February and July.

† Annual Report of Chief of Engineers, p. 592.

‡ The species described by me as *Bathmodon* constitute a section of this genus, characterized by the absence of tubercle or ridge between the inner cusps of the last lower molar. I do not maintain this section as a distinct genus.

§ See Report of the U. S. Geol. Surv. Terrs., 4to, ii, pp. 33–39.

‖ Ann. Report U. S. Geol. Surv. Terrs., 1873 (1874).

Mountains, yet some of the genera are identical, and others closely correspondent, as follows:—

Wahsatch.	Suessonien.
Ambloctonus.	Palæonyctis.
Hyracotherium.	Hyracotherium.
Coryphodon.	Coryphodon.
Diatryma.	Gastornis.
Lepidosteus.	Lepidosteus.

As a point of difference between the beds, may be mentioned the absence of the *Tæniodonta* from the Suessonian, a sub-order not yet known out of North America.

The Wahsatch formation includes the Green River Beds of Hayden, a name which I formerly used for the entire series. It, however, applies properly to the fish shales of Green River, containing *Asineops*, *Clupea*, *Osteoglossum*, etc., which are probably local in their character.

The Bridger formation will then represent on the American continent, more nearly than any other, the Middle Eocene or Parisien of Cuvier, Brongniart, and Renevier.

The teeth of sharks described in the reports quoted are of uncertain origin. They are associated with oyster shells, and both have the appearance of having been transported; nevertheless, some of the mammalian teeth found associated with them have a similarly rolled appearance. It therefore remains uncertain whether the ocean had for a limited time access to the Eocene lake, or whether the shark's teeth and *Ostreæ* were derived from the Cretaceous beds which formed its shores. Similar, and in one instance the same species of sharks were found in both formations, the division of the Cretaceous being No. 3 and 4 of Hayden.*

In conclusion, the classification of the North American Eocene may be represented as follows:—

Formation.	Equivalent.	Locality.	Characteristic Fossils.
Bridger Form.	Middle Eocene.	S. W. Wyoming.	Palæosyops. Tillodontia. Dinocerata.
Wahsatch Form.	Lower Eocene.	N. E. New Mexico, S. W. Wyoming.	Coryphodon. Tæniodonta. Phenacodus. Diatryma.

2. *Note upon the Geological position of the Serpentine Limestone of Northern New York, and an inquiry regarding the relations of this Limestone to the Eozoon Limestones of Canada*, by Prof. JAMES HALL.—(The following is an abstract of this paper read before the American Association at Buffalo.) On the geological map of the State of New York now before you, you will observe a large area in the northern part of the State, colored of a light reddish tint. The formations occupying this space were originally termed Primary, and more recently Laurentian. They constitute

* The same state of things exists in the siderolitic deposits of the Canton of Vaud, Switzerland. Mingled with the mammalian remains are teeth of sharks, of which M. La Harpe remarks that their appearance does not warrant the belief that they have been transported, or are not indigenous to the Eocene fauna.

the oldest rock formations of the State, as well as of the eastern part of the continent, although we well know that they represent several geological periods.

The counties of Essex, Warren and Hamilton are almost entirely occupied by rocks of the Laurentian system proper, while a large part of Clinton, Franklin, and a considerable portion of Saratoga and Herkimer, are occupied by the same geological formations.

The eastern part of Saratoga and Warren and the shore of Lake Champlain, in Essex and Clinton counties, are marked by the presence of the Postdam and Calciferous sandstone and the Chazy and Trenton Limestones, one or all of them; and the northern part of Clinton presents a broad outlying area of the Potsdam sandstone, which stretches westward across Franklin and St. Lawrence counties and thence into Canada.

The rocks of the lower division of the Laurentians consist of black hornblendic, gray garnetiferous and coarse feldspathic and quartzose gneisses, with extensive beds of magnetic iron ore. These are succeeded by massive beds of labradorite rock—the hypersthene rock of Emmons and other granite rocks. This part of the formation is marked by extensive beds of titaniferous iron ore. The succession is however unconformable, and the interval between the two series of rocks is not determined, nor does it appear to be determinable from examinations thus far made within the State of New York.

Associated with these gneissic and labradorite formations are one or more bands of crystalline limestone—the primary limestone of Emmons. This limestone is usually and perhaps always permeated by serpentine in grains, bands, or what sometimes appear as concretionary or aggregated masses of that mineral. This limestone in the eastern counties of northern New York has been considered a part of the Laurentian series, and is thus treated I believe by all geologists.

Having, in 1866, been occupied in some critical examinations of the region in the neighborhood of Port Henry and Westport, I became satisfied that the limestone of that neighborhood did not form a part of the lower Laurentian series of strata, but unconformably overlaid the upturned edges of the gneissic beds of that portion of the system. Neither does it conform to the upper or labradorite portion of the system. Having had occasion to pass over the same region almost annually since that period I have been confirmed in my previous observations.

The limestone in the neighborhood of Port Henry is usually a heavy bedded crystalline limestone with grains and blotches, and more rarely layers of serpentine. Sometimes it is conspicuously brecciated, and contains fragments of gneissoid rock which seem to have been derived from the strata below, upon which the rock lies unconformably. The same belt of limestone occurs at intervals, flanking the Laurentian rocks to the southward, and is conspicuously present in the town of Minerva, and it is apparently the same belt which is known in Warren county. From the latter locality it has been reported as containing Eozoon.

The limestones of St. Lawrence and Lewis counties are usually more coarsely crystalline, with larger bands of serpentine, and with a somewhat different association of minerals, from those of the eastern counties, and the identity of the two is not proven. Nevertheless these limestones, last referred to, with their associated beds of granitic and other rocks, with specular iron-ore, are not of true Laurentian age, and their relations to the latter are at present not well determined, except that they are of more recent date in the geological series.

The simple point which I wish to demonstrate is that this limestone of Essex and adjacent counties does not belong to the Laurentian system, either lower or upper. That it is a formation deposited along the flanks of, and within the Laurentian area, at a period subsequent to the deposition, metamorphism and disturbance of the rocks of authentic Laurentian age, and that it apparently holds a place in the series between the Laurentian and Potsdam periods, but whether of Huronian age or otherwise I do not pretend to say, and it may even prove of later date than this.

With these facts before us it becomes a matter worthy of inquiry, whether the Eozoon limestones of Canada, which are associated with Laurentian rocks and have been referred to that age, are really Laurentian, or hold the place and position of those of Northern New York.

Note.—Since preparing the statement giving views here presented, I have been informed that Mr. Vennor, of the Canadian Geological Survey, in a paper read before the Natural History Society of Montreal, has expressed an opinion that the Eozoon limestones of Canada are not of Laurentian age. Not having seen the communication I am only able, at the present time to add this note, but with the permission of the Association will make a more extended reference in the final publication.—*Buffalo Courier*, Aug. 25.

3. *On the Geology of the Southern Counties of New York and adjacent parts of Pennsylvania, especially with reference to the Age and Structure of the Catskill Mountain Range;* by James Hall (Proc. Amer. Assoc., 1875, p. 80).—The object of this paper is mainly to state and illustrate the results of four years of labor, chiefly in the southern counties of New York and the adjacent northern portions of Pennsylvania, by Mr. Andrew Sherwood, assisted by Mr. Clark Sherwood, under my direction.

The question has been raised regarding the existence of the Old Red Sandstone, or Catskill group, within the limits of New York, although a considerable area had been thus colored on the original geological map of the State.

The assertion of the non-existence of this formation in the State had induced me many years since to review some portions of my work of 1844, and, while in the main features it was found correct, it became evident that something farther was needed in the elucidation of the structure of the Catskill region. In fact, it became evident that one could travel from Schoharie county to the Penn-

sylvania line, on rocks of the Chemung group, without touching or seeing the Old Red Sandstone. And from this circumstance arose the statement of the absence of this formation from the State of New York. It became a very different matter, however, when one crossed the same region of country from east to west.

After several visits to this region, and notably one in 1857, with Sir William E. Logan and Andrew C. Ramsay, (the latter now Director of the British Geological Survey,) the question of the geological age of this great accumulation of strata assumed a still more important aspect; and the question has never been lost sight of; though for many years it has been quite impossible for me to undertake the investigation.

Referring to the Geological Map of New York, of 1843, a large area is colored as the Catskill Group without indication of geological structure. A similar feature was seen in northern New York; where the limits of the Laurentian system had barely been determined. Geological surveys have been carried on with too much haste, and under the pressure of necessity, from limited time; therefore it was, that we were compelled to content ourselves with determining the limits of formations, and not the structure, which required long and careful investigation.

In 1870, when for the first time I was able to give attention to this part of the country, there was no definite knowledge of the region; the record of the Geological Map had been controverted; and the non-existence of the Catskill or Old Red Sandstone, within the State of New York, was the prevalent opinion.

Mr. Sherwood was employed to begin his investigations in the spring of 1871, and has continued till the close of 1874. To accomplish the work represented on the map before you has, therefore, cost the labor of two men for four years. It now presents the aspect of a piece of work completed, except that from the erroneous maps of the State we are unable to give more than the approximate limits of the outcrops.

The work has not only accomplished what was undertaken, but has proved conclusively the existence (first suspected in 1857) of higher formations, lying upon the red Catskill rocks.

The entire region, from the base of the Catskill range to the western limits of the red rocks, in Chenango county, presents a series of nearly parallel anticlinal and synclinal folds; and the same structure is continued to the western limit of the State, although the red rocks may not appear within the State; and the formation probably thins out entirely, before reaching the western boundary of New York and Pennsylvania.

The topographical sketch presents a view of the Catskill range from the east side of the Hudson river, opposite to Catskill, looking over the shales of the Hudson River Group; the general dip of the rocks is perceptible in their inclination to the southward. In a cross section of this range, the dip of the strata to the northwest and southeast is shown, forming synclinal and anticlinal folds, of which five synclinals and six anticlinals are included in the extent given.

The expression of the map in its coloring shows the direction and extent of certain belts of red rock, which in some part of their extent are crowned by gray sandstone and conglomerate, referred to the Vespertine and Umbral formations of Professor Rogers, and regarded as belonging to the Carboniferous age.

These belts are the synclinal axes, which sometimes embrace the higher rocks within their folds, and have, in some localities, been so far eroded as to leave only a narrow belt of red rock; and even this has been in many places removed, and the erosion has penetrated deeply into the rocks of the Chemung Group.

Going to the south of the State line, these synclinals carry outliers of the Coal-measure, greater or less in extent, as shown by the map. In the Catskill region the general direction of these synclinals and adjacent anticlinals is from southwest to northeast; but farther to the westward they gradually decline in abruptness, and assume a more nearly east and west direction.

The anticlinals are everywhere valleys, along which the streams flow and the main roads of the country are made; the road from Kingston to Delhi being the principal exception. In going to the east or west of these we ascend over the rough and broken country formed by the outcropping of the Red Sandstone and Conglomerate. Owing to the great difficulty of crossing this country, we have long remained ignorant of its geological structure. The synclinals everywhere present high and broken ridges, and more especially so when the Vespertine and Umbral rocks form the terminal mass.

It is true that the Delaware and Susquehanna rivers both flow across or through these synclinals, in channels made by deep erosion.

The parallel ridges of the high country culminate in the Catskill mountains, where we have an elevation of nearly 4,000 feet above tide-water. The cause of this greater elevation is shown to be due to the convergence of three synclinals, which, presenting such a mass of material to the eroding forces, has prevented the anticlinals from being excavated below the red rocks of the Catskill formation. To this condition we are indebted for the higher portions of the range, which present, in a topographical aspect, only an irregularly scattered mass of mountain elevations.

The section exhibited, crossing the Catskill range from Schenevus to Glasco, is on a line south of the culminating ridges, and therefore does not present the highest points of the range. The lower rocks of the section are of the Chemung Group; but the relations of all these are shown on the smaller section from the Mohawk to Carbondale.

The lower beds shown, of Portage and Chemung, have a thickness of more than 2,000 feet; while the rocks above, which may be referred to the Catskill, are about 3,000 feet thick, and the higher beds, of Vespertine, extending to the summit of Round-Top, may be reckoned at about 800 feet.*

* That the entire mountain elevation above tide-water does not exceed 4,000 feet, is due to the dip of the strata, which makes the elevation so much less than the thickness.

The passage from the red rocks to the gray sandstone and conglomerate is gradual, with alternations of red and gray rocks, and does not afford any strong line of demarcation.

The remains of *Holoptychius*, in the form of bony plates, fragments of bone, etc., extend through a thickness of more than two hundred feet.

In its western extension, the red rock, with its alternations of green and mottled beds, shows a gradual thinning, and finally seems to be lost entirely.

One of the greatest difficulties met with in this investigation, has been the occurrence of red and greenish shales in the Chemung and Portage beds; and the finding of gray beds with Chemung fossils at an elevation of at least one hundred and fifty feet above the base of the red rocks, which had always been referred to the Catskill formation.

We have finally, however, ascertained, as I believe, the limits of the formation, and though not always in strong contrast with the rocks below, we have been guided both by physical and biological conditions.

In the interval between well-marked Chemung and typical Catskill, there are beds of intermediate character, and we sometimes find a few fossils of the lower rocks. The same means of distinction do not occur in all localities. In some places the indications of the Catskill are in the red shales and diagonally laminated sandstones. In other places we find a mass of vegetation, with or without the presence of the large Lamellibranch known as *Cypricardites Catskillensis.* The occurrence of this fossil may, in my opinion, be relied on as characterizing the base of the Catskill formation, while the *Holoptychius* marks the beds above, but still is not known above the middle of the formation.

Another question, involved in this investigation, has been the determinations of the relations of these red rocks to the superior sandstones and conglomerates, which in eastern New York and Pennsylvania are known as Vespertine and Umbral. The question also as to the character of these latter rocks in their western extension, is one of great interest, and whether the Waverly sandstones of Ohio may or may not be a continuation of the former.

In some localities in the border counties of western Pennsylvania, the rocks regarded as the Waverly Group of Ohio, rest directly upon the Chemung; and the fossils of the Chemung pass into the higher beds and mingle with other species regarded as Carboniferous forms.

Indeed, from the little I have seen, I should say, that in the region referred to, there are more species of fossils passing from the Upper Chemung into the Waverly formation, than there are species passing from the lower to the upper division of the Chemung group proper.

The question is of great interest in view of the supposed horizon of Carboniferous forms; but if we are able to substantiate the foregoing proposition, I think it will be shown that the Chemung

fauna continued its existence till after the appearance of Carboniferous forms, and that the two faunas, if they can be properly so regarded, lived in the same sea and at the same epoch; and the question of the limits between Devonian and Carboniferous formations, is likely, at least for some time, to remain undetermined in some parts of the country.

The work is still unfinished in the western part of the State; but we have indications of what we may expect to find on farther investigation.—*Proc. Amer. Assoc.*, Detroit, 1875, p. 80.

4. *On the Erosion of Rocks;* by E. B. Andrews. (Communication to the Editors, dated Lancaster, Ohio, Sept., 1876.)—Attention having been recently called to the subject of erosion by the excellent papers of Mr. G. K. Gilbert, I beg a little space to present one feature of the weathering of rocks, which may be worthy of more consideration than it has received.

In some counties in Ohio, where the Waverly sandstone assumes a coarse semi-conglomeratic character, and in our Coal-measures where the sand rock is coarse and massive, we find many narrow valleys bordered by high cliffs, from fifty to two hundred feet high. These cliffs often overhang their bases forming recesses of from thirty to one hundred and fifty feet in depth from a vertical line dropped from the top. These rock-walled valleys when followed up are often found to terminate in semi-circular cliffs over which the little streams fall in pretty cascades. Behind the falls we find large semi-circular or crescent-shaped caverns, forming recesses sometimes large enough to hold regiments of men. The streams are generally very small and often become dry in the summer. They have worn for themselves only slight channels in the top rock,—the rock-roof of the cavern—but the point where the water strikes below is too far away from the side walls of the cavern to admit of any direct erosion, or of any mechanical undermining of the cliff. Ordinarily the whole range of the cavern wall is dry. But not so in time of freshet. Then the water comes down with great force of concussion, and the cavern becomes a "cave of the winds." The spray is driven into the inmost recesses and the moisture with the help of frost disintegrates the rocks. This spray from muddy waters leaves a coating of mud upon the walls of the cavern. Thus spray becomes the agent of undermining the cliff, just as the coal-miner makes his "bearing-in" in the lower part of the coal seam. In time, the projecting table-rocks fall and the valley is practically formed. In this way an enormous amount of valley erosion has been produced in sandstone regions.* A fine illustration of valley-making by means of a spray-formed cavern may be seen near the "Ash Cave," in the western part of Hocking County, Ohio. The Ash Cave is itself only a remnant of a spray-cavern. The overhanging cliff formed a dry and desirable shelter, and the recess was long

* The erosion at the Falls of Niagara, by spray driven by wind against the shale, is referred to by Lyell, in his account of the region given in his "Travels in North America," page 26, and also by Prof. James Hall in his New York Geological Report.

used by Indians, who have left upon its floor a large accumulation of the ashes of their fires,—a pile 100 feet long by perhaps 30 feet wide, and two and a half feet deep,—in which I have found buried human bones, seeds, and many Indian relics. The water-fall, with its semi-circular cavern, is a hundred rods above the Ash Cave. A similar large spray cavern is found on a small tributary of Salt Creek, a few miles below Jackson, in Jackson County. Here the rock is a Coal-measure conglomerate. I have seen hundreds of these caverns in coarse heavy-bedded sandrocks of the West.

It may be well to add to the foregoing statement the fact that there are, in the Waverly sandstone region, numberless valleys with terminal circular arched cliffs, which in the retrocession of the falls have been carried so far back toward the top or center of the dividing ridges as to leave for themselves drainage areas quite too small to afford water enough to continue the work of cañon-making. The streams, being only small affluents of the larger ones, and often not more than half a mile long, were at first large enough, when in freshet, to make the spray caverns and to remove the waste at the foot of the terminal cliffs. But now, with drainage area above the falls reduced to almost nothing, the water, even in its highest stage, is too feeble a porter to carry away the waste, and the heads of the cañons are slowly filling up from local disintegration, etc. The famous Rock House, in Hocking County—pictured in Ohio Geol. Report for 1870, p. 83—is an illustration of cañon-making in its last stages. The little stream, which has worked out the cañon, is probably not more than half a mile long from head to outlet, and of this length three-quarters are below the falls. The terminal cliff is 115 feet high. This cliff is near the summit of a hill, and the drainage of very few acres forms the insignificant brooklet that trickles over the edge and down the face of the rock. The whole length of the top edge of the cliff from side to side of the chasm is probably not less than 500 feet. The streamlet which, when I saw it, a child might almost divert from its course by a shingle, has changed its place from time to time, and so has operated along the whole face of the cliff. At the point back of the spot where the waters, when in freshet, must now strike the bottom is a small recess, formed by the weathering action of the spray. A small channel is kept open below the falls, but the stream is able now to carry away only a small part of the waste of the cliff and the wash of the soil above the cliff, and the work of filling up has begun. The Rock House, proper, is a magnificent corridor high up in the cliff, formed by the action of the little stream passing down a crack parallel to the face of the rock and finding outlets in transverse cracks.

5. ***Report on the Geology of the Eastern portion of the Uinta Mountains, and a region of country adjacent thereto;*** by J. W. Powell. 218 pp. 4to., with plates and sections, and also a folio atlas. Washington, 1876.—Major Powell, in this sequel to his Report on the Colorado region published in 1875, embraces, be-

sides the results of his study of the Uinta Mountains, a general consideration of the wide range of facts he has observed in the West. He gives, in systematic form, the views he has arrived at with regard to the nature of the mountain structures of the region, and the system in the faults, folds, and displacements of the rocks; also detailed sections of the series of sedimentary strata involved in the displacements, from the lowest rocks to the top of the Tertiary, and the distribution of these rocks in the Uinta Mountains; finally, he treats of the special structure of these mountains, and of the methods and results of their degradation. The subject of displacements is admirably illustrated by his plates, two of which are stereographic; and, owing to the bare condition of the surface, the facts have been made out with an exactness and amount of detail impossible in regions of soil and forests. An excellent feature of the work is the natural scale of all its sections, in place of the usual exaggerations. The views are partly those adopted by Mr. Gilbert. We propose to cite at length from the volume in another number of this Journal. The Report also contains a Paleontological Report by Prof. C. A. White, treating of Carboniferous, Jurassic, Cretaceous and Tertiary Invertebrate fossils, some of them new species.

6. *On a Gigantic Bird from the Eocene of New Mexico*, by Prof. Cope. (Proc. Acad. N. S. Philad., Feb., 1876.)—Prof. Cope exhibited a tarsometatarsus of a bird, discovered by himself during the explorations in New Mexico conducted by Lieut. G. M. Wheeler, U. S. A. The characters of its proximal extremity resemble in many points those of the order *Cursores* (represented by the *Struthionidæ* and *Dinornis*), while those of the distal end are, in the middle and inner trochleæ, like those of the *Gastornis* of the Paris Basin. Its size indicates a species with feet twice the bulk of those of the ostrich. The discovery introduces this group of birds to the known faunæ of North America recent and extinct, and demonstrates that this continent has not been destitute of the gigantic forms of birds, heretofore chiefly found in the Southern Hemisphere faunæ. The description is as follows:

The hypotarsus is moderately prominent, with a broad truncate face, and does not inclose the ligamentous groove of its inner side. Its superior angle is broken away in the specimen. The two foramina which pierce the shaft just below the head, are well separated from each other both on the posterior and anterior faces, marking nearly equal thirds of the transverse diameter of the bone. The cotyloid cavities for the tibio-tarsus are bounded by an elevated margin, and are separated medially by a single low oblique ridge. The groove of the posterior face is particularly wide, and the inner part of the shaft is thinned, while the outer border is broadly convex. The proximal part of the inner border (as far as it is preserved) is marked with a flat surface which is roughened with ridges, which is perhaps the sutural articulation of the proximal end of the metatarsus of the hallux. No such surface exists on the corresponding bone of the ostrich or emeu. Only two of the

free distal phalangeal extremities are preserved. The shaft is broken, showing that its interior is filled with cancellous tissue. The free extremities are remarkable for the great inferior extent of the articular trochlear face. The median is strongly grooved with an obtuse excavation, and the lateral or bordering ridges are equal and rounded. The groove is continuous with the superior surface, but not with the inferior. There the convergent lateral ridges inclosing the open groove, terminate in an abrupt elevation above the adjacent surface of the shaft. The sides at this point are concave. The inner free condyle has an oblique articular face, the external ridge dropping away internally as in many birds, and produced beyond the inner ridge, distally. The articular face becomes then a part of a spiral, and is little grooved above, but strongly grooved medially. The vertical diameters of the sides differ, the inner being much greater, and both are concave. A strong foramen pierces the shaft just within the point of junction of the inner and medial free extremities.

Measurements.		m.
Transverse diameter of proximal end of tarsometatarsus		·100
Antero-posterior do. (partly inferential)		·070
Interval between penetrating foramina on anterior face shaft		·017
Median distal condyle	Long diameter	·050
	Vertical diameter	·048
	Transverse diameter	·040
Internal distal condyle	Long diameter	·037
	Vertical diameter	·040
	Transverse diameter	·031

The large size and wide separation of the penetrating foramina, and the thin internal edge with suturul articular facet, distinguish this form as distinct from any of the genera of Struthionidæ and Dinornithidæ. It is therefore named *Diatryma gigantea.*

7. *Fifth Annual Report of the Geological Survey of Indiana made during the year* 1873; by E. T. Cox, State Geologist. 494 pp. 8vo, with maps.—This volume contains a general report by Professor Cox; a report on Clarke and Floyd counties, by W. W. Borden; on Warren, Lawrence, Knox, and Gibson counties, by Mr. John Collett; and observations in DeKalb and other counties, by G. M. Levette.

Footprints of Labyrinthodont character, found by Mr. Collett near the base of the Coal Measures in Warren county, are described and figured; they are 1¼ to 1½ inches long, and 1 to 1¼ broad, all 5-toed, and the stride is three inches. The species is named by Prof. Cox *Collettosaurus Indianensis.*

A *tripoli*, from "pockets" in the cherty limestone above Coal K, in Dubois county consists, according to Dr. J. Gardner, almost wholly of spicules of sponges; and in one cherty nodule from the same vicinity, there was, in a cavity near its center, a slight network of the glassy filaments of the sponge, about which concretion took place, indicating, as stated by Dr. Gardner, that the hornstone nodules found in the cherty beds correspond each to a fossil sponge.

Several *terraces* exist on the border of Lake Michigan, near Michigan City, the highest of which—the fifth—is elevated 225 feet above the lake. The fourth is 95 feet above the same level, and contains much coarse gravel.

8. *Fossil Plants of the Coal-measures of Terrera, in the Atacama district, Chili.* (Bull. Soc. Geol. de France, III, iii, 572, 1876.)—The plants are Jurassic, of the Lower Lias or Rhætic beds, and included *Jeanpaulia Münsteriana* Presl., *Angiopteridium Münsteri* Gœpp., a *Pecopteris* (*P. Fuchsi*), near *P. Gœppertiana.*

III. Botany and Zoology.

1. *Sensitive Stigmas as an aid to cross fertilization of Flowers;* by Prof. W. J. Beal, (Proc. Amer. Assoc., Buffalo.)—The flowers of *Martynia proboscidia,* a plant sometimes raised in our gardens for pickles, has flowers drooping at an angle of about forty-five degrees. At the opening on the upper side are two flat stigmas, curved back away from each other, exposing the surface which is sensitive to pollen. Farther on are the four anthers, side by side, with their cells placed end to end. The opening is just large enough to take in the humble bee, or the common hive bee will do as well.

I have been carefully watching the Martynia plants for several weeks, since they have been in flower, every day and at nearly all hours and sometimes several times a day. I have the plants in four places, two of which are beds about four feet by ten. They are among other beds of flowering plants which are freely visited by various kinds of insects. I felt quite sure that the humble bee transferred pollen on his back, because I found the stigmas covered with pollen and closed before night each day. I could not contrive how else the pollen could be transferred. I began to fear I should have to give it up. But, one morning about nine o'clock, I saw a single humble bee pass from flower to flower on nearly every specimen on one patch of plants. The visit lasted only a few moments. All parts are quite sticky with glutinous hairs which seem to annoy the bees very much. I have never seen but one bee on the flowers of Martynia; she alighted on the spotted, showy part of the corolla, and crawled, first hitting the stigmas.

One of the most interesting points is now to be explained. The stigmas are sensitive to the touch, and close up in five to ten seconds; often before the insect is ready to back out of the flower. If they are not quite closed at that time, the bee shuts them by pushing her back against the back of one of the stigmas. The lower lobe of the flat stigma next to the bee's back is the larger. No pollen can be left as the insect retreats. A cross of pollen is usually certain. If not very freely dusted with pollen the stigmas open again in about fifteen minutes; if well dusted I have known them to remain closed afterward.

The single flat stigma of the iris, one on each of three sides of the flower, has often been shown to be sure of cross-fertilization, if

fertilized at all. Some years ago I examined hundreds of specimens as they were fertilized by bees. The stigma closes up after it is covered with pollen. It is sensitive to the touch; perhaps only slowly, but I think it moves back in a few seconds. I have examined no specimens lately with special reference to this point. The stigmas of *Mimulus ringens* are curved out like those of the Martynia, and project beyond the anthers. I have seen small native Hymenoptera visit this plant, always crawling in with the back down, although Mühler says in personate flowers the bees always get their backs up as they pass in. The stigmas of this *Mimulus* are slowly sensitive, closing in a few moments after they are touched or well supplied with pollen. The stigmas of the *Mimulus luteus* and *Mimulus moschatus*, and likely other species, close very quickly after being touched. *Tecoma radicans* and *Tecoma grandiflora* and probably other species, are very much like Martynia in the peculiarities mentioned. I have not lately had the opportunity of examining the flowers of the Bigonia or Catalpa but I shall expect to find them cross-fertilized in the same way as Tecomia aided by sensitive stigmas. *Utricularia vulgaris*, one of our larger common bladderworts, has a yellow irregular flower which considerably resembles that of the snap-dragon. The stigmas act much as in Martynia. The lower lip of the stigma is much the larger and when touched bends up close against the upper lip of the corolla just under an arch-like projection. The other nice adaptions for securing cross-fertilization are rather complicated and need not be given at this time.

Pinguicula is quite similar in structure to the Utricularia and is likely sensitive in its stigmas, and fertilized in the same way. All the stigmas which I have seen that are sensitive, stand with one side toward the space visited by insects, and if there are two together, the larger stigma comes next to the body of the insect. —*Buffalo Courier*, Aug. 25, 1876.

2. *On the theory of Evolution;* by Prof. COPE. (Proc. Acad. Nat. Sci. Philad., Feb., 1876.)—Prof. Cope gave a history of the progress of the doctrine of evolution of animal and vegetable types. While Darwin has been its prominent advocate within the last few years, it was first presented to the scientific world, in a rational form, by Lamarck of Paris, at the commencement of the present century. Owing to the adverse influence of Cuvier, the doctrine remained dormant for half a century, and Darwin resuscitated it, making important additions at the same time. Thus Lamarck found the variations of species to be the primary evidence of evolution by descent. Darwin enunciated the law of "natural selection" as a result of the struggle for existence, in accordance with which "the fittest" only survive. This law, now generally accepted, is Darwin's principal contribution to the doctrine. It, however, has a secondary position in relation to the *origin* of variation, which Lamarck saw, but did not account for, and which Darwin has to assume in order to have materials from which a "natural selection" can be made.

The relations exhibited by fully grown animals and plants with transitional or embryonic stages of other animals and plants, had attracted the attention of anatomists at the time of Lamarck. Some naturalists deduced from this now universally observed phenomenon, that the lower types of animals were merely repressed conditions of the higher, or in other words, were embryonic stages become permanent. But the resemblances do not usually extend to the entire organism, and the parallels are so incomplete, that this view of the matter was clearly defective, and did not constitute an explanation. Some embryologists, as Lereboullet and Agassiz, asserted that no argument for a doctrine of descent could be drawn from such facts.

The speaker, not adopting either view, made a full investigation into the later embryonic stages, chiefly of the skeleton of the Batrachia, in 1865, and Prof. Hyatt, of Salem, Mass., at the same time made similar studies in the development of the Ammonites and Nautili. The results as bearing on the doctrine of evolution were published in 1869 (in "The Origin of Genera"). It was there pointed out, that the most nearly related forms of animals do present a relation of repression and advance, or of permanent embryonic and adult type, leaving no doubt that the one is descended from the other. This relation was termed *exact parallelism.* It was also shown, that, if the embryonic form were the parent, the advanced descendant was produced by an increased rate of growth, which phenomenon was called *acceleration;* but that, if the embryonic type were the offspring, then its failure to attain to the condition of the parent is due to the supervention of a slower rate of growth; to this phenomenon the term *retardation* was applied. It was then shown that the *inexact parallelism* was the result of *unequal* acceleration or retardation; that is, acceleration affecting one organ or part more than another, thus disturbing the combination of characters which is necessary for the state of *exact parallelism* between the perfect stage of one animal and the transitional state of another. Moreover, acceleration implies constant addition to the parts of an animal, while retardation implies continual subtraction from its characters, or atrophy. He has also shown (Method of Creation, 1871), that the additions either appeared as *exact repetitions* of preëxistent parts, or as *modified repetitions*, the former resulting in simple, the latter in more complex organisms.

Professor Hæckel, of Jena, has added the keystone to the doctrine of evolution in his Gastræa theory. Prior to this generalization, it had been impossible to determine the true relation existing between the four types of embryonic growth, or, to speak otherwise than that they are inherently distinct from each other. But Hæckel has happily determined the existence of identical stages of growth (or segmentation) in all of the types of eggs, the last of which is the *gastrula;* and beyond which the identity ceases. Not that the four types of gastrula are without difference, but this difference may be accounted for, on plain principles. In 1874, Hæckel, in his "Anthropogenie," recognizes the importance of the

irregularity of time of appearance of the different characters of animals during their period of growth, as affecting their permanent structure. While maintaining the view that the low forms represent the transitional stages of the higher, he proceeds to account for the want of exact correspondence exhibited by them at the present time, by reference to this principle. He believes that the relation of parent and descendant has been concealed and changed by subsequent modifications of the order and appearance of characters in growth. To the original simple descent he applies the term *palingenesis;* to the modified and later growth, *cœnogenesis.* The causes of the change from palingenesis to cœnogenesis, he regards as three, viz: acceleration, retardation, and heterotopy.

It is clear that the two types of growth distinguished by Prof. Hæckel are those which had been pointed out by Prof. Cope in "The Origin of Genera," as producing the relations of "exact" and "inexact parallelism;" and that his explanation of the origin of the latter relation by acceleration or retardation is the same as that of the latter essay. The importance which he attaches to the subject was a source of gratification to the speaker, as it was a similar impression that led to the publication of "The Origin of Genera" in 1869.

It remains to observe that the phenomena of exact parallelism or palingenesis, are quite as necessarily accounted for on the principle of acceleration or retardation, as are those of inexact parallelism or cœnogenesis. Were all parts of the organism accelerated or retarded at a like rate, the relation of exact parallelism would never be disturbed; while the inexactitude of the parallelism will depend on the number of variations in the rate of growth of different organs of the individual, with additions introduced from time to time. Hence it may be laid down, that *synchronous acceleration* or *retardation* produces exact parallelism, and *heterochronous acceleration* or *retardation* produces inexact parallelism.

In conclusion, it may be added that acceleration of the segmentation, the protoplasma or animal portion of the primordial egg, or retardation of segmentation of the deutoplasma or vegetative half of the egg, or both, or the same relation between the growth of the circumference and center of the egg, has given rise to the four types which the segmentation now presents.

An analysis of the laws of evolution may be tabulated as follows:—

Acceleration, which proceeds by	Exact repetition. Modified repetition. Heterotopy.
Retardation, which proceeds by	Exact atrophy. Inexact atrophy (or senility),*

and each of the methods may be either of *Exact parallelism*, the product of *Palingenseis*, which is *synchronous;* or *Inexact parallelism*, the product of *Cœnogenesis*, which is *heterochronous.*

3. *Mimicry in Butterflies explained by Natural Selection;* by S. H. Scudder. (Proc. Amer. Assoc., Buffalo.)—Fritz Müller,

* So called by Professor Hyatt.

whose contributions to science are always worthy of especial attention, endeavors in a recent German periodical to show how the phenomena of mimicry in butterflies may be explained by the theory of natural selection. He bases his inquiries upon the species of Leptalis found in southern Brazil; and although, as will appear below, he adduces reasons for believing the primitive stock to have been banded, and not, like most of the family to which the genus belongs, simple white butterflies, he commences by showing how even such an extreme change could be wrought out by the survival of the fittest in the struggle for existence. "Should," he remarks, "the first unimportant variations from the original white color (of the Pierids) be useful only in attracting to their possessors, at a little shorter distance, the attention of enemies flying constantly overhead, they would become more and more useful, and cause their possessors to become continually more abundant in proportion to the type, they could therefore serve as the basis for the gradual formation of a resemblance fit to deceive even the sharp eyes of birds scanning the swarms of Ithonias (the butterflies imitated by some Leptalids) for booty." Further on he asserts that "the acceptance, as the starting point in the origin of mimicry by natural selection, of a resemblance having its beginning at such a distance, can scarcely be shaken by a single known case. It should moreover not escape attention that the sharpsightedness of enemies is itself also a quality at first gradually acquired in the struggle for existence, and one which must increase from the very fact that by protective coloring, mimicry, &c., the persecuted species escapes the less sharp-sighted pursuer. This ever increasing sensitiveness and sharpsightedness of the pursuer on the one hand explains the wonderful completeness of many natural imitations, and, on the other, makes the acceptation of an originally very slight resemblance the less hazardous."

Fritz Müller insists, as all writers on the subject have done, upon the similar geographical distribution of the imitating and the imitated species, as a necessary concomitant of mimicry, but instead of believing, with the other authors, that the Leptalids have become poor flyers in their imitation of the feeble-winged Ithonias; he holds that the wretched powers of flight possessed by the species of Leptalis have been the very cause of mimicry; the insects needed mimicry the more the poorer flyers they were. Mimicking species, of course, stand between their original type and the mimicked species; and, since mimickry is often confined to the female, we should expect in such cases to find the following series: original form, male of mimetic species, female of same. Species mimicked. In his vicinity, Müller has found five species of Leptalis, of which only four are common and discussed by him. Of these four, *Leptalis melia* mimics nothing; all the other three are imitative species, and mimic distinct groups of butterflies; *Leptalis astynome*, resembling a Heliconian-like Danaid, *Mechanitis Lysimnia*; another, which he calls *Leptalis thalia*, mimicking an Acræan, *Acræa thalia*, so closely that Müller at first supposed it to be an Acrean;

and the last, *Leptalis melite*, bearing a close resemblance to the female of one of its own family, *Leptoneura Lycinunia.*—*Buffalo Daily Courier*, Aug. 25, 1876.

4. *A Preliminary Note on Menopoma Alleghaniensis of Harlan;* by A. R. GROTE, (Proc. Amer. Assoc., Buffalo, 1876.)—I have been able to examine nearly one hundred specimens of the Menopoma Alleghanense, the aquatic salamander living in the tributaries of the Mississippi, taken in the months of July and August in the Alleghany river, at Olean, N. Y. The object of the present communication is to record the fact that the more reddish unicolorous specimens, which have been described as a distinct species under the name of *fuscum* by Holbrook, and which are retained as a distinct species by Prof. Cope in his check list, cannot be considered as a different species from the spotted specimens from which the original description seems to be drawn. We have one species in the tributaries of the Ohio and Mississippi, and not two. The larger, and apparently often the female specimens, are referable to Holbrook's name. Between the two there seems to be all possible grades, and from the same locality, although the two extremes are more numerous, and, at first sight, readily picked out.

I have also to record the fact that the animal sheds a transparent membrane, which I believe is the exterior layer of the skin. While observing this fact in the aquarium of the Buffalo Society of Natural Sciences, Prof. S. W. Garman and myself were able to find an almost complete skin, all the feet and the toes being readily perceived while floating and unfolding it in the water. This same skin was observed at first gathered in the mouth of the animal, which was apparently in the act of swallowing it. This last observation is interesting, since a similar habit had been previously observed in the case of the common toad. All individuals of the Menopoma that I have observed have in the water an intermittent swaying motion from side to side. While I have not been able to verify the conjecture, this movement of the body may be connected with the effort of the animal to get rid of its skin. On the other hand it may be a movement to attract the sexes, or connected with the breeding period.

In *Dactylethra* and *Cyclorhamphus* Prof. Garman has observed a similar shedding of the skin. We may predict that the same thing occurs in the other more exclusively aquatic forms *Necturus tetradactylus* (*Menobranchus lateralis* of authors), *Amphiuma*, *Siren*, and also in the forms that take to the land, as *Amblystoma*, *Plethodon*, *Desmognathus*, and *Diemyctylus*, as well as in *Megalobatrachus* of Japan.

I have to record also the fact that females opened on August 21st, contained well developed eggs attached by a membrane to the ovary.

I finally wish to record the important fact that the eggs are deposited in August. (I exhibit one taken from the aquarium this morning, Aug. 30th, 1876.) The yolk is seen floating freely in a glairy fluid, enveloped in a membrane similar to that containing

the albumen in a bird's egg inside the shell. The eggs are laid in a connected string and impregnations probably occur as they are extruded. The egg takes in water by endosmosis.

The Menopoma frequents the muddy banks of the river, in which to secrete its eggs. In external appearance there is at this time a change, and we may say that the animal puts on its "marriage dress." The tail broadens and there is a plaited extension of the skin, along the sides of the body. The *Menopoma* is nocturnal in its habits.

5. *The Entomological Section of the American Association, Buffalo, N. Y. Address of* Dr. LeConte, *President of the Section.*—After noticing some of the evidences of progress in new publications, etc., Dr. LeConte added:

I would gladly stop here, but a sense of duty to science, and my obligation to you alike forbid silence. I have to speak of a subject of a disagreeable nature.

It is concerning the efforts made by you and other members of the Association at the last meeting at Detroit, to procure the appointment of a Commission for the protection of Agriculture against noxious insects: this Commission to be composed of properly informed men of science, and chosen under such circumstances as would prevent the influence of political bias, or personal favoritism. If I do not fatigue your memory too much, you will recollect the memorials that were so extensively signed, in relation to this subject; copies of which memorials are again before you. These memorials were extensively circulated at the West, and were signed by many of the most influential bodies for the promotion and protection of agriculture in that region. During the winter these memorials were sent to Congress, in the expectation that some proper legislation would follow. One of the Senators, in fact, introduced a bill which seems to have been very carefully considered, and indeed bears upon its face some evidence of scientific guidance. This bill provided for the appointment of three Commissioners for five years: the Commissioners to be nominated by the Council of the National Academy of Sciences to the Secretary of the Interior. This bill, having been referred to the Committee on Agriculture, was returned so altered in form as to provide for one Commissioner, to be appointed by the Department of Agriculture, the very enemy and incubus from which the western agriculturists specially desired to be relieved.

The bill in this form passed the Senate, several of the members taking occasion in the discussion which preceded the passage, to talk to the demonstration of their own ignorance of the subject. However, this discussion has been already so severely commented upon in several of the newspapers of the Mississippi valley, that it is quite unnecessary for me to add anything farther, except the hope that the Legislature which chooses the successors of those Senators will have men of better education and higher intelligence offered to them as candidates for the position.—*Buffalo Daily Courier*, Aug. 25, 1876.

6. *Manual of the Vertebrates of the Northern United States;* by D. S. JORDAN. 12mo, 342 pp., no figures. Chicago: 1876. (Jansen, McClurg & Co.)—To collectors and others who chiefly desire to ascertain the names of species, this will doubtless prove to be a very convenient and useful work, especially if they have already acquired considerable familiarity with the subject by the use of more elaborate works. But it will prove of little value as a genuine Natural History of our vertebrates. Inasmuch as works of this class naturally tend to foster the already too prevalent idea that the study of "zoology" and "botany" means only, or chiefly, the learning of the names and habits of animals and plants, they may, in many cases, do more to hinder than to help the true progress of these sciences. In the present work we find little more than the shortest and most meagre descriptions of the species, usually without any reference whatever to habits, while the characters of the genera cannot be ascertained, in most cases, except by the use of "analytical tables," which are, for the most part, highly artificial.

The descriptions of the families and orders are likewise very brief and technical. At most, it should be regarded only as a convenient key or index to the names and classification of the species included in it. But on this very account, the absence of synonyms and of all references to more important works, in which the species are fully described or figured, is a very serious defect, which renders it far less useful than it otherwise might have been. A mere list of the numerous important works from which the author has compiled his book would have been of far more use to most students than any other part of the book of similar extent. Although the author, in the preface, admits that he has compiled his materials from numerous authors, he seldom indicates, in the body of the work, from what special work, or even from what author, a statement or description has been borrowed. The reliability of such compilations depends so directly upon the works used in compilation, that some indication should always be given of the source of the statements, and this could easily have been done without materially increasing the size or cost of the book. The copious index and glossary at the end are good features.

There are, as might have been anticipated, many inaccuracies, and also some important omissions of species. The genus *Neosorex*, of which a species (*N. palustris*) was described by the writer from Maine and Massachusetts,* and by Prof. Cope, from New Hampshire, is not mentioned at all. There are but two species of *Sorex* mentioned, while there are certainly three, and perhaps four species in New England. *Blarina angusticeps*, a well marked form, is also omitted. The American bears are all reduced to one species, in accordance with Mr. J. A. Allen's former views, which, however, he has since discarded, as noticed in the last number of this Journal. Among the fishes, where there is some original matter, the author has, in some genera, rejected or ignored many species

* Proceedings Boston Soc. Natural History, vol. ix, p. 164, 172, 225, 1862. See also *N. fimbripes* (Bachman, sp.) from Pennsylvania.

recognized by other writers, which is an easy, if not satisfactory, way, of jumping difficult subjects. This is especially the case in the Salmonidæ and Catostomidæ. V.

7. *The Five Senses of Man;* by JULIUS BERNSTEIN. International Scientific Series. 301 pp., 91 wood-cuts. New York: 1876. (D. Appleton & Co.)—In this work the author has presented very clearly, and in a pleasing manner, the more important facts and theories concerning this interesting subject, together with statements of the numerous observations and experiments recently made, relating to the senses. As many of these recent investigations are not included in the text-books and treatises ordinarily used, this book will be of general interest. V.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the fall of a Meteorite in Kansas City, Missouri, in June,* 1876; by JOHN D. PARKER. (Letter to Editors dated Kansas City, Mo., Aug. 2, 1876.—On June 25, 1876, between the hours of nine and ten in the morning, a small meteorite fell upon the tin roof of Mr. Isaac Whittaker's business house, No. 556 Main street, Kansas City, Mo. The meteorite came down with sufficient force to cut a hole in the tin roof on the front part of the house near an open window, but not passing entirely through the tin, it bounded back a few feet and lay on the roof. Mrs. Baker, who occupies rooms in the front part of the house in the second story, and Mrs. Whittaker were standing near the window when the meteorite fell, and heard the sharp concussion when it struck the roof. Mrs. Baker immediately picked up the meteorite as it lay near her on the roof, but dropped it again, finding it too hot to retain it in her hand.

The meteorite is a plano-convex specimen, about one and three-quarter inches in diameter, and about one-third of an inch in thickness. The outside or convex surface possesses the usual crusted appearance, while the inside or plane surface differs from ordinary meteorites in possessing the appearance of sulphuret of iron, subjected to some degree of heat, instead of nickeliferous iron. One might easily infer that the meteorite was shaled off from a large bolide that passed over the city at that time. As it fell in the city, I have named it the Kansas City Meteorite. It has not been subjected to chemical analysis.

2. *American Association for the Advancement of Science, at Buffalo.*—The meeting of the Association at Buffalo opened on Wednesday, on the twenty-third of August. Prof. WILLIAM B. ROGERS was the President of the meeting. The address of the retiring President, Mr. J. E. HILGARD, of the Coast Survey, treated of the recent progress in the department of Geodesy, and especially of the work accomplished in the United States. There were addresses also by the Vice-Presidents of the sections, Prof. C. A. YOUNG giving a review of recent Astronomical progress, Prof. E. S. MORSE, of work done in North America in connection

with the subject of Evolution; and Prof. G. F. BARKER treating of "the Atom and the Molecule."

The number of members present was large, and the hospitality of the citizens of Buffalo unbounded. Besides other entertainments, there was, without expense to the members, an excursion on Saturday to Niagara Falls, where a generous lunch was furnished them by Mr. John L. Bush at his mansion; and on the following Wednesday, over the Chautauqua Lake, to Jamestown, seventy miles. Between four and five hundred persons went on these excursions.

A number of distinguished foreign men of science were present—among them Prof. Huxley; Prof. Otto Torell, Dr. J. Lindahl and J. Nordström, of Sweden; Prof. E. H. von Baumhauer, of Haarlem; Mr. W. Sagel, of Vienna; R. Kœnig, of Paris; and Signor Castellani, of Rome. Prof. Huxley was received with a vote of welcome amid much applause.

The officers elected for the next meeting of the Association are as follows: Prof. SIMON NEWCOMB, President; Prof. EDWARD C. PICKERING, Vice-President of the Physical section; Prof. O. C. MARSH, Vice-President of the section of Geology and Natural History; Prof. N. T. LUPTON, Chairman of the Chemical subsection; Prof. DANIEL WILSON, Chairman of the subsection of Anthropology; R. H. WARD, Chairman of the subsection of Microscopy; A. R. GROTE, General Secretary; F. W. PUTNAM, Permanent Secretary; WM. S. VAUX, Treasurer. The Association adjourned to meet in 1877, at Nashville, Tennessee, on the last Wednesday of August.

The following is a list of the papers read at the meeting or accepted for reading.

I. *Physical Section.*

On the practicability of cooling the air of buildings during hot weather; S. NEWCOMB.

Note on the radiometer, T. C. MENDENHALL.

Certain new constructions in graphical statics, H. T. EDDY.

Spectroscopic observations on the sun's rotation, C. A. YOUNG.

On some recent spectroscopic observations of the zodiacal light, A. W. WRIGHT. Volatilization of metals by the electrical discharge, id.

On Kent's table of one-quarter squares of numbers, S. J. COFFIN.

A new fundamental method in graphical statics, H. T. EDDY.

On the Iowa weather stations, G. HINRICHS.

Phenomena produced by the union of two sounds, R. KŒNIG.

Discussion of the general principles of construction of ordinary and perfect magic squares, J. D. WARNER.

Physics of the Gulf of Mexico and the Mississippi River, C. G. FORSHEY.

Solar influence on the degradation of soils by aqueous action, T. MCWHORTER.

The specific gravity of lead, P. SCHWEITZER.

Co-ordinate surveying, H. F. WALLING.

Some remarks on the use and interpretation of particular integrals which satisfy general differential equations expressive of dynamic problems, suggested by Laplace's dynamic theory of the tides, J. G. BARNARD.

Determinations of subjective temperature, J. W. OSBORNE. The accurate graduation of thermometers by comparison, id. Experiments on the gyration of liquid masses in rotation, id.

Observations on the diurnal variation in the humidity of the air, H. HAMBERG.

On the increase of index of refraction accompanying change of temperature, T. C. MENDENHALL.

Dielectric polarization, E. ROOT.

Essay on the molecular character of steam, S. M. ALLEN.

A tide gauge for use in cold climates, J. M. BATCHELDER.

Meteorites of Amana, Iowa Co., Iowa, G. HINRICHS.

On the distribution of errors in numbers written from memory, F. E. NIPHER.

Account of a series of experiments on the refrigeration of air by expansion, P. H. Van der WEYDE.

On the combined compression and stage-forceps carrier, R. H. WARD.

Proposed method of evolution, J. D. WARNER.

Exhibition of capillary coke, from Tracy City, Tenn., N. T. LUPTON.

Relative market prices of gold and silver, and their influence on the metallic monetary standard of the United States, E. B. ELLIOTT. Prices of the bonded securities of the United States and the corresponding rates of interest realized to investors, id.

II. *Section of Geology and Natural History.*

On the mode of extrusion of the ova in Limpets, W. H. DALL.

On the origin of kames or eskers in New Hampshire, W. UPHAM.

Some new points regarding the tongue of Picus viridis, J. LINDAHL.

On the geology of Eastern Pennsylvania, T. S. HUNT.

Note upon the geological position of the serpentine limestone of Northern New York, and an inquiry regarding the relations of this limestone to the Eozoon limestone of Canada, J. HALL.

On the plastidule hypothesis, L. ELSBERG.

On self-fertilization and cross-fertilization in flowers, T. MEEHAN. On graft hybrids, id.

The water-lime group of Buffalo, A. R. GROTE and W. H. PITT.

On the provisional hypothesis of Pangenesis, W. K. BROOKS.

On a new species of Argulus, A. H. TUTTLE. Notes on the myriapods of Ohio, id.

The slight morphological value of natural attitude and numerical composition, B. G. WILDER. Notes on the brains of fish-like vertebrates; myxinoids, sharks and skates, chimæra, teleosts, id. Notes on the North American Ganoids, id.

The origin and mode of formation of the Great Lakes, J. S. NEWBERRY.

The relations of the rocks of Ohio to those of Pennsylvania and New York, id.

Principal characters of American Pterodactyles, O. C. MARSH.

Note on the pitchstones of Arran, F. A. GOOCH.

On *Sycotypus canaliculatus* Linn., F. W. SIMONDS.

A brief comparison of the butterfly faunas of Europe and eastern North America, with hints concerning the derivation of the latter, S. H. SCUDDER.

On the reciprocal relations of certain genera of articulated brachiopods, W. H. DALL.

New facts relating to *Eozoön Canadense*, J. W. DAWSON.

On the siphon of Endoceras, a genus of chambered shells, A. WINCHELL.

On the post-glacial history of Sequoia gigantea, J. MUIR.

Variation in color in animals, S. W. GARMAN.

Description of new fungus on the leaves of the pear tree, W. H. SEAMAN.

The edible crab of Maryland, *Callinectes hastatus* (Ordway), P. R. UHLER.

Phyllotaxis of cones, W. J. BEAL. Can the Unios see? id. Cross-fertilization of the apple blossoms, id. Sensitive stigmas as an aid to cross-fertilization of flowers, id.

Biological notes on the army worm (*Leucania puncta* Haw), C. V. RILEY.

A preliminary note on *Menopoma Alleghaniensis* of Harlan, A. R. GROTE.

On the origin of mineral veins, C. WHITTLESEY.

A supplement to the glacial theory, W. C. KERR.

Evidences in Boone Co., Ky., of glacial or ice deposits of two distinct and widely distant periods, G. SUTTON.

On the burial place of the Yorkshire Mastodon, discovered in Broome Co., N. Y., T. B. COMSTOCK. Some unexplained phenomena in the Geyser Basins of the Yellowstone National Park, id. The "two-ocean water," the union of the Atlantic and Pacific Oceans in the Rocky Mountains, id.

III. *Subsection of Chemistry.*

The relationship of structure, density and chemical composition in steel, J. W. LANGLEY.

On the limit of reliability in the indirect estimation of sodium and potassium chlorides, H. W. WILEY. Some modified forms of apparatus; flue with artificial draft, flue with artificial draft and air bath, apparatus for sugar and fat extraction, id. Some indigenous Indiana woods, their specific gravity, per cent of ash in wood and bark, id.

On the chemical composition of a saline efflorescence occurring at Goat Island, E. W. MORLEY.

A note upon the rocks of the Galapagos Islands, F. A. GOOCH.

On the chemical composition of Pennsylvania petroleum, S. P. SADTLER.

Contribution to the chemistry of hydrogen, A. R. LEEDS.

Upon the reduction of silver at ordinary temperatures in the presence of free nitric acid, id.

On a siliceous deposit from the interior of a hollow mass of limonite, with observations on the molecular movements of finely divided matter, N. T. LUPTON.

On the so-called alkali of the western plains, B. S. HEDRICK.

On the analysis of milk, E. H. v. BAUMHAUER.

Notes of a mineralogical tour in Western North Carolina, made under the auspices of the State survey, A. A. JULIEN and H. C. BOLTON.

A sugar analysis, A. SPRINGER.

Action of moderate heat on bituminous coal, E. T. COX.

Dissociation of phosphorus in the blast furnace, W. H. CHANDLER and E. H. BAILEY. Nitrates in natural waters and in Lechauweki spring water, id. Determination of nitric acid, id.

IV. *Subsection of Microscopy.*

Results of measurements of eleven of Möller's Diætomaceen Probe-platten, E. W. MORLEY.

Micrometric measurements of rulings on glass, by Mr. ROGERS.

Micrometric measurements of rulings on glass, by Mr. RUTHERFORD.

Results obtained by double staining of muscular tissue of Amphiura with picric acid and carmine, G. BEATTY.

Simple means of adopting the binocular microscope to defects in the eye, W. H. BULLOCK.

Remarks on some American contributions to the development of the modern microscope, R. H. WARD.

On a new system of finder for the microscope.

On a few simplifications of the polarizing and of the spectroscopic microscope.

On some modifications and special attachments to the microscope for chemical research, P. H. VAN DER WEYDE.

V. *Subsection of Anthropology.*

Peculiarities of the femora from tumuli in Michigan, H. GILLMAN. Investigation of the burial ground at Fort Wayne on the Detroit river, Michigan, id. Some observations on the orbits of the crania from mounds, id.

The international symbols for charts of prehistoric archæology, O. T. MASON. The scope of anthropology, and the classification of its materials, id. Archæological collections from Porto Rico, id.

The Iroquois phratry, L. H. MORGAN. The Iroquois gens, id. The Iroquois confederacy, id.

Etruscan and Greek art in Jewelry, and its revival, A. CASTELLANI.

Hybridity and absorption among the races of the New World, D. WILSON.

On the mythology of the North American Indians, J. W. POWELL.
Brain-weight and size in relation to the relative capacity of races, D. WILSON.
On some fragments of pottery from Vermont, G. H. PERKINS.
On the ancient and modern Pueblo tribes of the Pacific slope of the U. S., E. A. BARBER.
The mood of the verb in conditional clauses, ISAAC B. CHOATE.
The museums of industrial art in Austria, HEINRICH FRAUBERGER.
The archæology of Europe and America compared, S. D. PEET. On the state of society in the Primitive age, id.

3. *Geographical Distribution of Plants and Animals;* by C. PICKERING, Wilkes' U. S. Exploring Expedition, author of the Races of Man. Part II, Plants in their wild state. 524 pp. 4to, with several colored maps. Salem, Mass. (Naturalist's Agency.)—This work, completing Dr. Pickering's Report on the Geographical Distribution of Plants and Animals, is the result of extensive personal observation about the world as well as of much study. It is a large storehouse of facts, on a subject of general interest, gathered with great labor and fidelity. It gives observations with regard to the characteristic plants and predominant botanical features of all the various islands and continental regions visited by the Exploring Expedition under Captain (now Admiral), Wilkes, and also many collateral facts on climate, topography, scenery, etc., that came under the author's observation. The text is illustrated by maps of the world, presenting by colors the conclusions arrived at by the author.

4. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. 1, 1867–1876. 284 pp. 8vo, with 35 plates. Davenport, Iowa, 1876.—This first volume of the Proceedings contains a number of very valuable papers on mounds and mound-builders, by R. J. Farquharson, M.D., W. H. Pratt, A. S. Tiffany, C. Lindsley, and J. D. Putnam, with 34 plates, full of figures representing the structure of mounds, flint and other stone implements, pipes of the form of birds, frogs, and other animals, woven cloth, copper axes, awls, beads, and ear-drops, silver ear-drop, bone knives, pottery, skulls, etc., from different mounds, illustrating a paper by Dr. Farquharson. There are also Zoological articles by J. D. Putnam; Botanical notes by Dr. C. C. Parry; and lists of species of plants, and of land and fresh-water shells, of Coleoptera, Lepidoptera, Hymenoptera, of the vicinity of Davenport, besides other papers.

OBITUARY.

EBENEZER S. SNELL, of Amherst College, Massachusetts, Professor of Mathematics and Natural Philosophy, died, September 18th, aged seventy-five years.

Prof. CHARLES DAVIES, author of various mathematical works, a graduate of West Point of distinction, and from 1857 to 1867 Professor of Mathematics in Columbia College, died September eighteenth, in his seventy-ninth year.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXVIII.—*Observations on the Displacement of lines in the Solar Spectrum caused by the Sun's rotation;* by Professor C. A. YOUNG, of Dartmouth College.

[THE substance of this paper was read at the Buffalo Meeting of the American Association for the Advancement of Science, August 24th, 1876.]

Renewed interest in the question as to the effect of the motion of a luminous body in altering the wave length of the emitted light, has lately been excited by Van der Willigen's mathematical papers upon the subject, and the recent criticisms of Secchi upon the spectroscopic determinations of stellar motions published by Huggins, Vogel, Christie and others. The former, it will be recollected, impugns the received doctrine on mathematical grounds, and it must be acknowledged, that, although his reasoning is not admitted to be conclusive by most astronomers, it has produced a wide-spread distrust, which has been strengthened by the papers of Secchi. The objections of the latter seem however to have been fairly met by the reply of Mr. Christie, recently published in the Monthly Notices, showing the substantial agreement of the results obtained by the different observers after they had learned the delicate precautions essential to success in such observations.

Certainly it seems little short of self-evident that, whenever a point is communicating periodic vibrations to any medium whatever, and, by means of this medium, transmitting them to a second point at a distance, then the frequency, or virtual wave length, of these pulses received at the second point must

be affected by any relative motion of approach or recession between it and the source of the vibrations.

It is not difficult to verify this conclusion in the case of sound waves. The beautiful experiments of Vogel, lately published, show as the result of careful quantitative measurements, that the pitch of a locomotive whistle actually undergoes the precise alterations which theory requires, when the engine is either approaching the observer, or receding from him at a known velocity.

Undoubtedly a considerable point would be gained if we could obtain a similar verification in the case of light—if an alteration in the luminous pitch or wave length, produced in a ray of light by some known rate of motion, could actually be made sensible, measured, and shown to coincide with theory within observational limits of error. This verification unfortunately is not easy to obtain, because the velocity of light is so enormous that it is difficult to find an object sufficiently bright, and moving rapidly enough, to make the change of wave length perceptible in our instruments.

I think it was Zöllner who first suggested that the rotation of the sun might furnish the desired test, since its eastern and western limbs have a relative motion of nearly 2¼ English miles per second along the line of sight. But the displacement of lines in the spectrum due to this velocity is so small (in the case of the D lines about $\frac{1}{77}$ of the distance between them) that the dispersive power of the instruments heretofore employed by most observers, has been insufficient to make it clearly evident. Vogel alone (in 1871) seems to have succeeded in getting any measurements; his results for the sun's equatorial velocity of rotation ranging from 0·35 to 0·42 of a geographical mile, or from 1·62 to 1·94 English miles.

By using a diffraction grating, however, combined with a prism in such a way as to separate the overlapping spectra of the higher orders from each other, as described in my recent note* on the duplicity of the 1474 line, it is possible to obtain much greater dispersive power, and the displacement then becomes quite sensible.

The apparatus which I have employed consisted of a very fine diffraction grating of 8,640 lines to the inch (for which I am indebted to Mr. Rutherfurd) combined with a telescope and collimator each of 2½ inches aperture and sixteen inches focal length, and a prism of 45° inserted between the grating and the object glass of the eye-telescope. The refracting edge of the prism was of course perpendicular to the lines on the grating. The grating, collimator, &c., were mounted on a wooden framework constructed for the purpose, and arranged to be

* This Journal, June, 1876.

attached to the 9½ inch Equatorial of the Dartmouth College Observatory, in place of its ordinary spectroscope. Undoubtedly a metallic mounting would have been firmer and better, but with careful manipulation the wooden arrangement answered reasonably well. The eye-telescope and collimator were at a fixed inclination, and the spectra of the different orders were brought into the field of view by turning the grating in the plane of dispersion. This of course made the dispersive power quite different for the spectra of the same order on opposite sides of the image of the slit. The eye-telescope magnified about twenty times and was provided with a micrometer* borrowed from one of the reading microscopes of the meridian circle.

Between the two D lines, the spectra of the sixth and eighth orders usually showed no less than eight other lines, most of which are supposed to be water lines, produced by the vapor in our atmosphere, and therefore of course not subject to displacement by the sun's rotation. I was in hopes to make use of them as reference points, and to determine the displacement of the D lines by simply measuring the intervals with the micrometer. I soon found, however, that the atmospheric lines were too faint and shadowy to admit of sufficient accuracy of bisection, especially by the rather coarse threads with which the micrometer had been provided for the purpose of observing in a feeble light. I was accordingly compelled to make the observations as follows—

The grating having been adjusted so as to bring the group of lines to be observed into the center of the field of view, the spectroscope was turned around the optical axis of the telescope until the slit was accurately north and south, so that, if placed tangent to the eastern limb of the sun, a motion of the Right Ascension tangent screw would bring the western limb to tangency. Of course proceeding in this manner the observations were made at points not precisely on the sun's equator, but having a solar latitude ranging from 2° to 15°, according to the date. It was thought better to do this, however, than to risk the disturbance which might be produced by using the Declination tangent screw, which sometimes worked a little jerkily. The slit was then accurately adjusted to the focal plane of the sun's image, and the collimator and the eye telescope were focused carefully for distinct

* The value of one revolution of the micrometer screw (whose head was graduated into 60 divisions,) was about 4′ 9″; but it was continually varying by a slight amount, since in adjusting for distinct vision of the spectrum no pains was taken to keep the distance between the object glass and the cross hairs strictly constant. This will account for the small variations of the measured intervals between the same lines as determined on different occasions—variations considerably exceeding the probable errors of reading.

vision; after this no adjustment of either telescope or spectroscope was touched in the slightest until the observation was complete. The slit being placed nearly tangent to the limb of the sun, and the driving clock started, a series of micrometer readings was made upon the different lines in the group to be observed, first running the micrometer wires one way and then back, thus obtaining two readings for each line. Then the Right Ascension tangent screw was gently turned until the opposite limb was brought to the slit, and the micrometer readings were repeated, running down and back *twice*, so as to give four readings of each line; finally, moving the tangent screw so as to bring back the limb first observed, another set of readings was taken, two on each line, which finished the observation. The object of this arrangement of readings is of course to detect any possible disturbance of the instrument during the work, and to eliminate the effect of the earth's rotation, or of any uniformly progressive change in the relative positions of the collimator, grating, and eye-telescope, due to slight alterations of flexure caused by the motion of the telescope. Each reading given in the following tables is therefore the mean of four. The probable error of a single reading (due to inaccuracy of bisection or instrumental disturbance, but not of course including possible constant errors) was found to be about $\frac{3}{10}$ of one micrometer division; so that the probable error of each reading given in the tables is about 0·15 of a division.

It did not occur to me until near the end of the observations that, with the slit *tangent* to the sun's image, the heat would tend to displace the line of collimation by expanding the slit-plate more on one side than the other, and slightly bending the tube to which it is attached. Since, however, the effect would be in opposite directions according as the grating was inclined so as to throw the reflected slit-image to the right or the left, this effect must be nearly eliminated from the final mean. In some of the observations of Aug. 12, it was eliminated by inverting the spectroscope, i. e., rotating the whole spectroscope 180°, around the line of collimation; this, however, in one of the series of readings always brings the eye-piece into an inconvenient position. One set of observations on Aug. 12, was made with the slit *radial* to the sun's image—in this case the heat of the image has no injurious effect, but it is much more difficult to point the micrometer on the *end* of a line than on its middle, and the probable errors of reading are more than doubled.

The formulæ employed in reducing the observations are as follows: Let U = the relative velocity of two opposite points of the sun's equator, and $d\lambda$ the corresponding change of wave length of a spectrum-line, whose wave length is λ; also let the

velocity of light = 186600 English miles per second, according to the latest determination of Cornu. Then, by Doppler's theory,

$$U = 186600 \times \frac{d\lambda}{\lambda}. \qquad (1)$$

If now, in any group or spectrum lines of small extent, I is put for the difference of wave length of the extreme lines of the group; Δ for the interval between the extreme lines measured in micrometer units, and δ for the displacement as indicated by the difference between the micrometer readings on a given line when the slit is placed on the eastern and western limbs of the sun's image respectively, we shall have

$$d\lambda = \mathrm{I} \times \frac{\delta}{\Delta}, \text{ and } U = 186600 \frac{\mathrm{I}}{\lambda} \times \frac{\delta}{\Delta}, \qquad (2)$$

where λ of course is to be taken as the *mean* wave length of the group.

Taking Angström's wave lengths, we find for the D group $U = 190{\cdot}3 \frac{\delta}{\Delta}$, and for the 1474 group $U = 361{\cdot}1 \frac{\delta}{\Delta}$; which amounts to saying that a velocity of 190·3 English miles would displace one of the D lines by a space equal to the distance between them, and for the other group a velocity of 361·1 miles would be required.

From the sun's known dimensions and period of rotation, adopting Faye's numbers, the equatorial velocity of its surface is easily found to be 1·248 English miles per second; U, of course, ought to come out double this, or 2·496.

The tables need little explanation; the expression "grating right," means that the grating was so inclined as to throw the reflected image of the slit to that side of the collimator which was remote from the eye-telescope. In this position the spectra were more dispersed, but less satisfactorily defined than those of the same order obtained by turning the grating "left," i. e., toward the eye-telescope. The first column contains the designation of the line observed; the second, headed "west," gives the reading of the micrometer obtained at this limb; the fourth, headed "east," gives the reading of the eastern limb; the third, headed "mean," contains the mean of the numbers in the second and fourth columns, expressed in divisions of the micrometer head; the difference between these, given at the bottom of the column is Δ. The fifth column contains the differences between the numbers in the second and fourth columns, and their mean, given at the bottom of the column, is δ.

In the earlier observations of the D group several other lines were observed besides the three given, but they were so faint that the readings were very discrepant, sometimes to the extent

of two or three divisions, and they are therefore omitted. The readings of the nickel line are retained, though far less reliable than those of the two Ds.

(1.) July 10, 1876; 9.30 to 10.15 A.M. (civil time); grating *right*; spectrum of 6th order; definition poor.

	West.		Mean.	East.			
	r	d	d	r	d		
D_1	4	45·65	284·70	4	43·75	1·90	$\frac{\delta}{\Delta}=0·0186$
Ni	3	52·90		3	49·75	2·15	U=3·55
D_2	2	59·00	178·05	2	57·10	1·90	
			$\Delta=106·65$			$\delta=1·98$	

If we reject the nickel line $\delta'=1·90$, $\frac{\delta'}{\Delta}=0·0178$

and U′=3 33.

(2.) July 10; 10.30 to 11.10 A.M. D lines; grating *right;* spectrum of 6th order; definition medium.

	West.		Mean.	East.			
	r	d	d	r	d	d	
D_1	4	26·40	265·57	4	24·75	1·65	$\frac{\delta}{\Delta}=0·0187$
Ni	3	32·05		3	29·65	2·40	
D_2	3	39·95	158·97	3	38·00	1·95	U=3·57
			d $\Delta=106·60$			$\delta=2·00$	

Rejecting the nickel line, $\delta'=1·80$; $\frac{\delta'}{\Delta}=0·0169$. U′=3·22.

(3.) July 10: 11.35 to 12.00 A.M. D lines; grating *left;* spectrum 6th order; definition fine.

	West.		Mean.	East.			
	r		d	r	d	d	
D_1	4	13·50	253·87	4	14·25	0·75	$\frac{\delta}{\Delta}=0·0126$
Ni	4	51·00		4	51·82	0·82	
D_2	5	16·87	317·28	5	17·70	0·83	U=2·40
			$\Delta=63·41$			$\delta=0·80$	

(4.) July 15; 10.15 to 10.40 A.M. Observation interrupted by clouds when half completed. D lines; grating *right;* spectrum 6th order; definition poor.

	West.		Mean.	East.			
	r	d	d	r	d	d	
D_1	5	08·40	308·15	5	07·90	0·50	$\frac{\delta}{\Delta}=0·0061$
Ni	4	12·70		4	12·00	0·70	U=1·16
D_2	3	22·05	201·67	3	21·30	0·75	This observation is entitled
			$\Delta=106·48$			$\delta=0·65$	to little weight.

(5.) August 10; 9.30 to 10.40 A. M. Twice the usual number of readings taken. D lines; grating *left;* spectrum 7th order; definition excellent.

	West. r	West. d	Mean. d	East. r	East. d	d	
D_1	0	33·30	33·27	0	34·25	0·95	$\frac{\delta}{\Delta}=0·0146$
Ni	1	13·47		1	15·00	1·53	U=2·78
?	1	36·25		1	37·40	1·15	This observation deserves *double* weight, on account of the number of readings and lines observed.
D_2	1	52·92	113·45	1	53·97	1·05	
			d $\Delta=80·18$			$\delta=1·17$	

(6.) August 10; 11.10 to 11.50 A. M. D lines; grating *right;* spectrum 6th order; definition poor.

	West. r	West. d	Mean. d	East. r	East. d	d	
D_2	2	18·70	137·63	2	16·55	2·15	$\frac{\delta}{\Delta}=0·0188$
Ni	1	25·65		1	22·85	2·80	U=3·59
D_2	0	32·05	31·52	0	31·00	1·05	
			$\Delta=106·11$			$\delta=2·00$	

Rejecting the nickel line, $\delta'=1·60$, $\frac{\delta'}{\Delta}=0·0151$ $U'=2·87$.

(7.) August 12; 9.30 to 10.10 A. M. 1474 group; grating *left;* 8th order; definition fine;* instrument *inverted.*

	West. r	West. d	Mean. d	East. r	East. d		
K 1463_2	2	51·72	172·22	2	52·72	1·00	$\frac{\delta}{\Delta}=0·00783$
1467	3	51 00		3	52·28	1·28	U=2·66
	4	49·65		4	51·60	1·95	
1474	5	49·20	349·71	5	50·23	1·03	
			$\Delta=177·49$			$\delta=1·31$	

(8.) August 12; 10.35 to 11.10 A. M. 1474 group; grating *left;* spectrum 8th order; instrument *erect;* definition fine.

	West. r	West. d	Mean. d	East. r	East. d	d	
K 1474	2	29·90	149·32	2	28·75	1·15	$\frac{\delta}{\Delta}=0·00666$
1467	4	28·00		4	26·82	1·18	U=2·41
1463_2	5	27·63	326·61	5	26·42	1·21	
			d $\Delta=177·29$			d $\delta=1·18$	

(9.) August 12; 11.30 A. M. to 12.20 P. M. 1474 group; grating *left;* spectrum 8th order; slit *radial;* definition fine.

	West. r	West. d	Mean. d	East. r	East. d	d	
K 1463_2	0	52·92	53·46	0	54·00	1·08	$\frac{\delta}{\Delta}=0·00651$
1467	1	52·85		1	54·15	1·30	U=2·35
1474	3	51·18	231·72	3	52·27	1·09	
			$\Delta=178·26$			$\delta=1·16$	

* The definition was such that 1474 constantly showed double, and on moving the slit to the base of the chromosphere, the bright line which appeared was clearly seen to coincide with the more refrangible of the two components.

Since the points observed were not situated upon the solar equator it is necessary to correct each result by multiplying it by a factor depending upon the heliographic latitude, φ, of the point. If the sun's surface rotated as a coherent mass the factor would be simply, sec. φ. Since this is not the case however, the expression becomes more complicated. Adopting Faye's constants and formula of solar rotation, we find the factor,

$$f=\frac{1}{\cos\varphi(1-0{\cdot}216\sin^2\varphi)}.$$

On July 10, $\varphi=2°$, $f=1{\cdot}001$; on July 15, $\varphi=3°$, $f=1{\cdot}002$; on Aug. 10, $\varphi=14°$, $f=1{\cdot}044$; on Aug. 12, $\varphi=15°$, $f=1{\cdot}051$.

Applying the corrections we have the following, in which the column headed Uε, gives the results without discrimination, while the column U$'\varepsilon$ contains the results obtained by throwing out the nickel line in observations (1), (2) and (6), and rejecting entirely (4), while (5) is counted twice, as having double weight for the reasons assigned.

	Uε		U$'\varepsilon$
(1)	3·55	(1′)	3·33
(2)	3·57	(2)	3·22
(3)	2·40	(3)	2·40
(4)	1·16	(4)	2·90
(5)	2·90	(5)	2·90
(6)	3·75	(6)	2·99
(7)	2·80	(7)	2·80
(8)	2·53	(8)	2·53
(9)	2·47	(9)	2·47
Mean	2·79 ± 0·18		2·84 ± 0·07

The two results do not differ materially, but the second is much more reliable. It makes the velocity of the sun's rotation 1·42 miles per second, while direct observation gives 1·25; perhaps the difference is no more than might be expected; still the difference of 0·34 between the values of U as determined spectroscopically and directly is so many times larger than the probable error of the spectroscopic result, that I am much inclined, especially considering the agreement with Vogel's result, to think it indicates a physical fact, and that the solar atmosphere really sweeps forward over the underlying surface, in the same way that the equatorial regions outstrip the other parts of the sun's surface. If the equatorial acceleration is produced by external causes such an effect would be likely.

It may be interesting to add, that on Aug. 10, a careful series of readings was made on a principal line of the B group, in the spectrum of the 6th order, with entirely negative results; as was to be expected, since the line is atmospheric. The mean of ten readings at the west limb was $56^d{\cdot}22$, at the east limb $56^d{\cdot}23$.

Hanover, N. H., Sept. 12, 1876.

ART. XXXIX.—*Researches in Acoustics*; by ALFRED M. MAYER. Paper No. 8, containing:

1. On the obliteration of the sensation of one sound by the simultaneous action on the ear of another more intense and lower sound.
2. On the discovery of the fact that a sound even when intense cannot obliterate the sensation of another sound lower than it in pitch.
3. On a proposed change in the usual method of conducting orchestral music, indicated by the above discoveries.
4. Applications of the interferences of sonorous sensations to determinations of the relative intensities of sounds.

THIS communication is preliminary to an elaborate paper on the above subjects. For conciseness and clearness, I present the few facts I have now to offer in the form of notes of experiments:—

1. *On the obliteration of the sensation of one sound by the simultaneous action on the ear of another more intense and lower sound.*

Experimental Observations on the Obliteration of one Sound by another.—Several feet from the ear I placed one of those loud-ticking spring-balance American clocks, which make four beats in a second. Then I brought quite close to my ear a watch (made by Lange, of Dresden) ticking five times in the second. In this position I heard all the ticks of the watch, even those which coincided with every fourth tick of the clock. Let us call the fifth tick of the watch which coincided with one of the ticks of the clock, its fifth tick. I now gradually removed the watch from the ear, and perceived that the fifth tick became fainter and fainter, till at a certain distance it entirely vanished, and was, so to speak, "stamped out" of the watch.*

Similar and more striking experiments were made with an old silver watch, beating four times to the second, by causing this watch to gain about thirty seconds an hour on the clock, so that at every two minutes the ticks of the watch and clock exactly coincided. When the watch was held near the ear, every one of its ticks was heard distinctly; but on gradually removing it from the ear, the ticks of the watch became fainter

* In the publication of this paper in Nature, Aug. 10, 1876, my friend Mr. Alexander J. Ellis, F.R.S., appends the following note to the above experiment:— "The precise number of ticks in a second here mentioned are not necessary for roughly observing and understanding these phenomena. I observed them by a common American pendulum clock placed on a table, which increased the power of its half-second ticks, and a watch beating five times in two seconds. Rev. Mr. Haweis informs me that he has often noticed a similar effect at night with ordinary watches. The sensation produced by the obliteration of the tick, when the proper distance of the watch from the ear has been attained, and the consequent sudden division of the ticks into periods separated by silences, is very peculiar. It is difficult not to believe that some accident has not suddenly interfered with the action of the watch, instead of merely with our own sensations."—A. J. E.

and fainter at the coincidences, and when the watch had been removed to a distance of nine inches from the ear, the ticks of the watch were utterly obliterated during *three* whole seconds of its ticks about the time of coincidence. On removing the watch to a distance of twenty-four inches, I found that I lost its ticks during *nine* seconds about the time of coincidence. It is here important to remark that the ticks of the clock are *longer* in duration, as well as *lower* in pitch, than those of the watch's. With the watch remaining at the distance of twenty-four inches from the ear, I listened with all my attention, as tick by tick the watch approached the time of coincidence. Since the ticks of the watch are shorter in duration than those of the clock, they are *overlapped* by the other about the time of coincidence. Hence as, so to speak, the short ticks of the watch glided tick after tick, under the long ticks of the clock, I perceived that more and more of the duration of each successive watch-tick became extinguished by the tick of the clock, until only the *tail* end of the short tick of the watch was left audible and at last even this also crept under the long tick of the clock and the whole of the ticks of the watch were rendered inaudible for *nine* seconds, at the end of which time the front or *head* of the watch-tick, as we may call it, protruded beyond the clock-tick, and then slowly grew up into a complete watch-tick as before. In this succession of events the tick of the old silver watch (made by Tobias) disappears with a sharp *chirp*, like a cricket's, and re-appears with a sound like that made by a boy's marble falling upon others in his pocket. By this experiment, therefore, a gradual analysis is made of the effect of the tick of the clock on the tick of the watch, affording a beautiful illustration of the fact that one sonorous sensation may overcome and obliterate another.

Experiments to determine the relative intensity of the Clock-ticks which obliterate the Watch-ticks.—The clock was placed on a post in the middle of an open level field in the country, on nights when the air was calm and noiseless. The ticks of the clock became just inaudible when my ear was removed to a distance of 350 feet. The ticks of the watch became just inaudible at a distance of twenty feet. The ratio of the squares of these numbers makes the ticks of the clock about 300 times more intense than those of the watch. On the same nights that I made the above determinations I also put the clock on the post and placing against my zygomatic process a slender stick graduated to inches and tenths, I stood with my ear at distances from the clock of from eight to sixteen feet, and then slid the watch above and along the stick (taking care that it did not touch it) until it reached such a distance from the ear that its fifth tick just disappeared. Knowing the relative intensities of the ticks of clock and watch when placed at the same distance

from the ear, the law of the reciprocals of the squares gives the relative intensities when the clock and watch are at the several distances obtained in the above experiments. Large numbers of such experiments have been made, and the results agree perfectly well when we take into consideration first, the difficulty thrown in the path of the determinations by the *gradual* fading away of the watch-ticks as they approach coincidence with the clock-ticks; and, secondly, the impossibility of arriving at *any* result at all, if the slightest noise (the rustle of a gentle breeze, the piping of frogs, the bark of a distant dog) should fall on the ear of the observer when engaged in making an experiment. The general result of the numerous experiments thus made shows that the sensation of the watch-tick is obliterated by a coincident tick of the clock, when the intensity of the clock-tick is *three times* that of the watch-tick. This result, however, must be regarded as merely approximative, not only from the manner in which it was obtained, but from the *complexity* of the sounds on which the experiments were made. It is interesting, however, both as being, I believe, the first determination of this kind that has ever been made, and as having opened out a new and important field of research in physiological acoustics.

Experiments on the Interference of the sensations of Musical Sounds.—Reserving the further development of my discoveries for future papers, I will now briefly describe some of the more prominent and simple phenomena, which I discovered in experimenting with *musical sounds.* At the outset I will remove an objection always made by those versed in acoustics, but unacquainted with these new phenomena. It is as follows:—"You say that one sound may obliterate the sensation of another; but are you sure that the real fact is not an alteration of the *quality* of the more intense sound by the action of the concurrent feebler vibration?" I exclude this objection by experimenting as follows:—An open or closed organ-pipe is sounded forcibly, and at a few feet from it is placed the instrument emitting the sound to be obliterated, which may be either a tuning-fork on its resonance box, or a closed organ-pipe communicating with a separate bellows. Suppose that in the following experiment both tuning-fork and closed organ-pipe produce a note higher in pitch than the more intense or extinguishing sound of the open organ-pipe. Now sound the fork alone strongly, and alternately shut and open its resonance box with the hand. We can thus obtain the sound of the fork in a *regular measure of time.* When the ear has well apprehended the intervals of silence and of sound thus produced, begin the experiment by sounding the open pipe and tuning-fork simultaneously Now, if any change is thus effected in the quality of sound emitted by the open pipe, this change cannot occur except when *the fork* is sounded, and hence, if it occurs at all,

it must occur in the regular measure in which the fork is sounded. The following are the facts really observed. At first every time that the mouth of the box is open, the sound of the fork is distinctly heard, and changes the quality of the note of the open pipe. But as the vibrations of the fork run down in amplitude, the sensations of its effect become less and less, till they soon entirely vanish, and not the slightest change can be observed in the quality or intensity of the note of the open organ-pipe, whether the resonance box of the fork be open or closed. Indeed at this stage of the experiment the vibrations of the fork may be suddenly and totally stopped without the ear being able to detect the fact. But if instead of stopping the fork when it becomes inaudible, we stop the sound of the open organ-pipe, it is impossible not to feel surprised at the strong sound of the fork which the open pipe had smothered and had rendered powerless to affect the ear. If we replace the tuning-fork by a closed organ-pipe of the same pitch, the results will be the same, but in this case I adjust the intensity of the higher closed pipe to the point of extinction by regulating the flow of air from the bellows by a valve worked with a screw. The alternation of sound and silence is obtained by closing and opening the mouth of the closed pipe by the hand.

2. *On the discovery of the fact that a sound even when intense cannot obliterate the sensation of another sound lower than it in pitch.*

High Sounds cannot obliterate Low Sounds.—A new and remarkable fact was now discovered. No sound, even when very intense, can diminish or obliterate the sensation of a concurrent sound which is lower in pitch. This was proved by experiments similar to the last, but differing in having the more intense sound higher (instead of lower) in pitch. In this case, when the ear decides that the sound of the (lower and feebler) tuning-fork is just extinguished, it is generally discovered on stopping the higher sound, that *the fork*, which should produce the lower sound, *has ceased to vibrate.* This surprising experiment must be made in order to be appreciated. I will only remark that very many similar experiments, ranging through four octaves, have been made, with consonant and dissonant intervals, and that scores of different hearers have confirmed this discovery. It is important to understand that this phenomenon depends solely on *difference* of pitch, and not at all on the absolute pitch of the notes. Thus a feeble c''' (1024 double vibrations) is heard as distinctly through an intense e''' (1280 double vibrations) as a feeble c (128 double vibrations) is heard through an intense g (192 double vibrations) or an intense c' (256 double vibrations).

The development of the applications and of the further illustrations of these discoveries would occupy too much space; I must therefore restrict myself to mentioning some of the most interesting. Let a man read a sentence over and over again with the same tone and modulation of voice, and while he is so doing forcibly sound a c' pipe (256 double vibrations). A remarkable effect is produced, which varies somewhat with the voice experimented on, but the ordinary result is as follows. It appears as though two persons were reading together, one with a grave voice (which is found by the combination of all the reader's real vocal sounds below c in pitch, or having less than 256 double vibrations), the other with a high-pitched voice, generally squeaky and nasal, and, I need not add, very disagreeable. Of course the aspirates come out with a distressing prominence. I have observed many curious illustrations of this change in the quality of the tone of the voice, caused by the entire or partial obliteration of certain vocal components, while listening to persons talking during the sound of a steam whistle, or in one of our long, resonant American railway carriages. Experiments similar to those on the human voice, can be made, with endless modifications, on other composite sounds, as those of reed-pipes, of stringed instruments, of running water, &c. With one of my c (128 double vibrations) free Grenié reeds, I get very marked results. Using as a concurrent sound an intense c' (256 double vibrations) I perceive the prime or fundamental simple tone c to be unaffected in intensity, while all the other partial tones (higher harmonics or overtones, as they are sometimes called) are almost obliterated, except the fifth partial (or fourth upper partial e'', of 640 double vibrations, and the sixth partial (or fifth upper partial) g'' (of 768 double vibrations), which come out with wonderful distinctness. The fact that the lowest, or prime partial tone in the majority of ordinary compound musical tones is strongest, is due (among other reasons) to the fact that the sensation of each partial tone of which the whole musical tone is composed, is diminished by the action on the ear of all the components or partial tones, *below* it in pitch. Thus the higher the pitch of any component or partial tone, the greater the number of lower components which tend to obliterate it. But the prime, or lowest component partial tone, is not affected by any other. Another illustration I cannot resist giving. At the end of the street in New York, in which I resided, there is a large fire-alarm bell, the residual sound of which, after its higher components have disappeared, is a deep simple tone. This bass sound holds its own with total indifference to the clatter of horses, or to any sounds *above* it in pitch. It dies out with a smooth gradient, generally without the slightest indentation or break produced by the other sounds of the street. Indeed, in this case, as in all others where one

sound remains unaffected by intense higher notes, the observer feels as though he had a special sense for the perception of the graver sound—an organ entirely distinct from that which receives the impress of the higher tones.

That one sonorous sensation cannot interfere with another which is lower in pitch, is a remarkable physiological discovery, and next after the demonstration of the fact that the ear is capable of analyzing compound musical sounds into their constituent or partial simple tones, is probably the most important addition yet made to our knowledge of the nature of hearing. It cannot fail to introduce profund modifications into the hypotheses heretofore framed respecting the mechanism and functions of the ear.

3. *On a proposed change in the usual method of conducting Orchestral Music, indicated by the above discoveries.*

We have seen how an intense sound may obliterate, entirely or in part, the sensations of certain partial tones or components of any musical tone, and thus produce a profound change in its quality. In a large orchestra I have repeatedly witnessed the entire obliteration of all sounds from violins, by the deeper and more intense sounds of the wind instruments, the double-bases alone holding their own. I have also observed the sounds of the clarinets lose their peculiar quality of tone and consequent charm from the same cause. No doubt the conductor of the orchestra heard all his violins, ranged as they always are close around him, and did not perceive that his clarinets had lost that quality of tone on which *the composer* had relied for producing a special character of expression.

The function of the conductor of an orchestra seems to be threefold. First, to regulate and fix the time. Secondly, to regulate the intensity of the sounds produced by the individual instruments, for the purpose of expression. Thirdly, to give the proper quality of tone or *feeling* to the whole sound of his orchestra, considered as a single instrument, by regulating *the relative intensities* of the sounds produced by the various classes of instruments employed. Now this third function, the regulation of relative intensities, has hitherto been discharged through the judgment of the ears of a conductor who is placed in the most disadvantageous position for judging by his ears. Surely he is not conducting for his own personal gratification, but for the gratification of his audience, whose ears stand in very different relations from his own in respect to their distance from the various instruments in action. Is it not time that he should pay more attention to his third function and place himself in the position occupied by an average hearer? This position would be elevated, and somewhere in the midst of the audience. The exact determination of its place would depend on various

conditions which cannot now be considered. That the position at present occupied by the conductor of an orchestra has often allowed him to deprive his audience of some of the most delicate and touching qualities of orchestral and concerted vocal music I have no doubt, and I firmly believe that when he changes his position in the manner now proposed the audience will have some of that enjoyment which he has too long kept to himself. During the past winter, in the Academy of Music at New York, and this spring at Offenbach's concerts, I fully confirmed all the foregoing surmises, by placing myself in different parts of the house to observe the different results, and my opinions were fully shared by others who have a more delicate musical organization than I can lay claim to.

In large orchestras, these interferences of sonorous sensations are so multiplied and various as to be beyond our mental conception. By taking them up in detail, some general laws may, however, be evolved. But it will be impossible to formulate such laws until, firstly, we are in possession of a *quantitative* analysis of the compound tones of all musical instruments (that is, until we know the relative loudness of the partial tones of which they are composed at all parts of their compass), and secondly, we have determined throughout the musical scale the relative intensities of the sounds (of simple tones) when obliteration of the sensations of higher (simple) tones supervenes. The powerlessness of one sound to affect the sensation due to another sound lower than itself in pitch greatly simplifies this problem.

4. *Applications of the interferences of sonorous sensations to the determinations of the Relative Intensities of Sounds.*

Quantitative analysis of the compound tones of musical instruments is now the great desideratum of the composer. It is only after we know the relative intensities of the components of typical musical tones used in orchestral performances, that we can so regulate their intensities as to give those qualities of sound which the composer desires to be heard. Thus, it at once becomes evident that the instruments used in orchestral music should be very differently constructed from those used for solos or quartets. In orchestral instruments certain *characteristic* upper partials (overtones, harmonics) should predominate, in order to find expression in the midst of other and graver sounds. Such orchestral instruments will therefore have exaggerated peculiarities in their qualities of tone, which will render them unfit to be played on alone, and uninfluenced by other orchestral notes. It is surely not hopeless to anticipate that empirical rules may be attained, which will guide the musical instrument-maker to the production of those special qualities of tone required in orchestral instruments. It is fortu-

nate that the very phenomena of the interferences of sonorous sensations will assist in the much desired solution of the problem of measuring the intensity of a sound (simple tone), either when existing alone or as component of an ordinary musical (compound) tone. On this subject I am now engaged. It is evident (by way of illustration), that so far as concerns the measure of the relative intensities of sounds *of the same pitch*, this problem has already received the simplest solution by merely placing these sounds at various distances, and obliterating the sensations they excite by means of a constant and standard sound of a lower pitch. But I reserve a description of this work for a more formal publication.

ART. XL.—*Address at the Glasgow Meeting of the British Association;* by Professor SIR WILLIAM THOMSON, President of the Mathematical and Physical Section.

A CONVERSATION which I had with Professor Newcomb one evening last June, in Professor Henry's drawing-room in the Smithsonian Institution, Washington, has forced me to give all my spare thoughts ever since to Hopkins's problem of Precession and Nutation, assuming the earth a rigid spheroidal shell filled with liquid. Six weeks ago, when I landed in England after a most interesting trip to America and back, and became painfully conscious that I must have the honor to address you here to-day, I wished to write an address of which science in America should be the subject. I came home, indeed, vividly impressed with much that I had seen, both in the Great Exhibition of Philadelphia and out of it, showing the truest scientific spirit and devotion, the originality, the inventiveness, the patient persevering thoroughness of work, the appreciativeness, and the generous openmindedness and sympathy, from which the great things of science come.

Θέλω λέγειν Ἀτρείδας
Θέλω δὲ Κυδμὸν ᾄδειν.

I wish I could speak to you of the veteran Henry, generous rival of Faraday in electromagnetic discovery; of Peirce the founder of high mathematics in America; of Bache, and of the splendid heritage he has left to America and to the world in the United States Coast Survey; of the great school of astronomers which followed, Gould, Newton, Newcomb, Watson, Young, Alvan Clarke, Rutherfurd, Draper, father and son: of Commander Belknap and his great exploration of the Pacific depths by pianoforte wire, with imperfect apparatus supplied from Glasgow, out of which he forced a success in his own way; of Cap-

tain Sigsbee, who followed with like fervor and resolution, and made further improvements in the apparatus by which he has done marvels of easy, quick, and sure deep-sea sounding in his little surveying ship *Blake*; and of the admirable official spirit which makes such men and such doings possible in the United States Naval Service. I would like to tell you too of my reason for confidently expecting that American hydrography will soon supply the data from tidal observations, long ago asked of our Government in vain by a Committee of the British Association, by which the amount of the earth's elastic yielding to the distorting influence of the sun and moon will be measured; and of my strong hope that the Compass Department of the American Navy will repay the debt to France, England, and Germany so appreciatively acknowledged in their reprint of the works of Poisson, Airy, Archibald Smith, Evans, and the Liverpool Compass Committee, by giving in return a fresh marine survey of terrestrial magnetism, to supply the navigator with data for correcting his compass without sights of sun or stars.

Can I go on to precession and nutation without a word of what I saw in the Great Exhibition of Philadelphia? In the U. S. Government part of it, Professor Hilgard showed me the measuring-rods of the U. S. Coast Survey, with their beautiful mechanical appliances for end measurement, by which the three great base lines of Maine, Long Island, and Georgia, were measured with about the same accuracy as the most accurate scientific measurers, whether of Europe or America, have attained in comparing two meter or yard measures.

In the United States telegraphic department I saw and heard Elisha Gray's splendidly worked-out electric telephone actually sounding four messages simultaneously on the Morse code, and clearly capable of doing yet four times as many with very moderate improvements of detail; and I saw Edison's automatic telegraph delivering 1,015 words in 57 seconds: this done by the long-neglected electro-chemical method of Bain, long ago condemned in England to the helot work of recording from a relay, and then turned adrift as needlessly delicate for that. In the Canadian department I heard "To be or not to be, ... there's the rub," through an electric telegraph wire; but, scorning monosyllables, the electric articulation rose to higher flights, and gave me passages taken at random from the New York newspapers:—"S. S. Cox has arrived" (I failed to make out the S. S. Cox); "The City of New York," "Senator Morton," "The Senate has resolved to print a thousand extra copies;" "The Americans in London have resolved to celebrate the coming Fourth of July." All this my own ears heard, spoken to me with unmistakable distinctness by the thin circular disc armature of just such another little electro-magnet as this which

I hold in my hand. The words were shouted with a clear and loud voice by my colleague-judge, Professor Watson, at the far end of the telegraph wire, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform in the neighborhood of an electro-magnet in circuit with the line motions proportional to the sonorific motions of the air. This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal, and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of invention which devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound?

The Patent Museum of Washington, an institution of which the nation is justly proud, and the beneficent working of the United States patent laws, deserve notice in the section of the British Association concerned with branches of science to which nine-tenths of all the useful patents of the world owe their foundations. I was much struck with the prevalence of patented inventions in the Exhibition: it seemed to me that every good thing deserving a patent was patented. I asked one inventor of a very good invention "Why don't you patent it in England?" He answered, "The conditions in England are too onerous." We certainly are far behind America's wisdom in this respect. If Europe does not amend its patent laws (England in the opposite direction to that proposed in the Bills before the last two sessions of Parliament) America will speedily become the nursery of useful inventions for the world.

I should tell you also of "Old Prob's" weather warnings, which cost the nation 250,000 dollars a year; money well spent say the western farmers, and not they alone: in this the whole people of the United States are agreed, and though Democrats or Republicans playing the "economical ticket" may for half a session stop the appropriations for even the United States Coast Survey, no one would for a moment think of proposing to starve "Old Prob;" and now that 80 per cent of his probabilities have proved true, and General Myers has for a month back ceased to call his daily forecasts "probabilities" and has begun to call them indications, what will the western farmers call him this time next year?

And the United States Naval Observatory, full of the very highest science, under the command of Admiral Davis! If, to get on to precession and nutation, I had resolved to omit

telling you that I had there, in an instrument for measuring photographs of the transit of Venus—shown me by Professor Harkness, a young Scotsman attracted into the United States Naval Service—seen for the first time in an astronomical observatory a geometrical slide, the verdict on the disaster on board the *Thunderer*, published while I am writing this address, forbids me to keep any such resolution, and compels me to put the question, Is there in the British Navy, or in a British steamer, or in a British land boiler another safety-valve so constructed that by any possibility, at any temperature, or under any stress it can jam? and to say that if there is it must be instantly corrected or removed.

I ought to speak to you, too, of the already venerable Harvard University, the Cambridge of America, and of the Technological Institute of Boston, created by William Rogers, brother of my late colleague in this university (Glasgow), Henry Rogers, and of the Johns Hopkins University of Baltimore, which with its youthful vigor has torn Sylvester from us, has utilised the genius and working power of Rowland for experimental research, and three days after my arrival in America, sent for the young Porter Poinier to make him a Fellow. But he was on his deathbed in New York "begging his physicians to keep him alive just to finish his book, and then he would be willing to go." Of his book, "Thermodynamics," we may hope to see at least a part, for much of the manuscript, and good and able friends to edit it, are left; but the appointment to a Fellowship in the Johns Hopkins University came a day too late to gratify his noble ambition.

But the stimulus of intercourse with American scientific men left no place in my mind for framing, or attempting to frame a report on American science. Disturbed by Newcomb's suspicions of the earth's irregularities as a Time-keeper, I could think of nothing but precession and nutation, and tides and monsoons, and settlements of the equatorial regions, and melting of polar ice. Week after week passed before I could put down two words which I could read to you here to-day: and so I have nothing to offer you for my Address but—

Review of Evidence regarding the Physical Condition of the Earth; its Internal Temperature; the Fluidity or Solidity of its Interior Substance; the Rigidity, Elasticity, Plasticity, of its External Figure; and the Permanence or Variability of its Period and Axis of Rotation.

The evidence of a high internal temperature is too well known to need any quotation of particulars at present. Suffice it to say that below the uppermost ten meters stratum of rock or soil sensibly affected by diurnal and annual variations of tem-

perature, there is generally found a gradual increase of temperature downward, approximating roughly, in ordinary localities, to an average rate of 1° C. per thirty meters of descent, but much greater in the neighborhood of active volcanoes, and certain other special localities of comparatively small area, where hot springs and, perhaps, also, sulphurous vapors prove an intimate relationship to volcanic quality. It is worthy of remark in passing, that, so far as we know at present, there are no localities of exceptionally *small* rate of augmentation of underground temperature, and none where temperature diminishes at any time through any considerable depth downward below the stratum sensibly influenced by summer heat and winter cold. Any considerable area of the earth of, say, not less than a kilometer in any horizontal diameter, which for several thousand years had been covered by snow or ice, and from which the ice had melted away and left an average surface temperature of 13°, would, during nine hundred years, show a decreasing temperature for some depth down from the surface: and thirty-six hundred years after the clearing away of the ice would still show a residual effect of the ancient cold, in a half rate of augmentation of temperature downward in the upper strata, gradually increasing to the whole normal rate which would be sensibly reached at a depth of 600 meters.

By a simple effort of geological calculus it has been estimated that 1° per 30 meters gives 1000° per 30,000 meters, and 3333° per 100 kilometers. This arithmetical result is irrefragable, but what of the physical conclusion drawn from it with marvellous frequency and pertinacity that at depths of from 30 to 100 kilometers the temperatures are so high as to melt all substances composing the earth's upper crust? It has been remarked, indeed, that if observation showed any diminution or augmentation of the rate of increase of undergroud temperature in great depths, it would not be right to reckon on the uniform rate of 1° per 30 meters, or thereabouts, down to 30 or 60 or 100 kilometers. "But observation has shown nothing of the kind, and therefore surely it is most consonant with inductive philosophy to admit no great deviation in any part of the earth's solid crust from the rate of increase proved by observation as far as the greatest depths to which we have reached!" Now I have to remark upon this argument that the greatest depth to which we have reached in observations of underground temperature is scarcely one kilometer; and that, if a 10 per cent diminution of the rate of augmentation of underground temperature downward were found at a depth of one kilometer, this would demonstrate* that within the last 100,000 years the

* For proof of this and following statements regarding Underground Heat I refer to "Secular Cooling of the Earth," *Transactions* of the Royal Society of Edinburgh, 1862, and Thomson and Tait's "Natural Philosophy," Appendix D.

upper surface of the earth must have been at a higher temperature than that now found at the depth of one kilometer. Such a result is no doubt to be found by observation in places which have been overflown by lava in the memory of man, or a few thousand years farther back; but if, without going deeper than a kilometer, a 10 per cent diminution of the rate of increase of temperature downward were found for the whole earth, it would limit the whole of geological history to within 100,000 years, or, at all events, would interpose an absolute barrier against the continuous descent of life on the earth from earlier periods than 100,000 years ago. Therefore, although search in particular localities for a diminution of the rate of augmentation of underground temperature in depths of less than a kilometer may be of intense interest, as helping us to fix the dates of extinct volcanic actions which have taken place within 100,000 years or so, we know enough from thoroughly sure geological evidence not to expect to find it, except in particular localities, and to feel quite sure that we shall not find it under any considerable portion of the earth's surface. If we admit as possible any such discontinuity within 900,000 years, we might be prepared to find a sensible diminution of the rate at three kilometers depth; but not at anything less than 30 kilometers if geologists validly claim as much as 90,000,000 of years for the length of the time with which their science is concerned. Now this implies a temperature of 1000° C. at the depth of 30 kilometers, allows something less than 2000° for the temperature at 60 kilometers, and does not require much more than 4000° C. at any depth, however great; but does require at the great depths a temperature of at all events not less than about 4000° C. It would not take much "hurrying up" of the actions with which they are concerned, to satisfy geologists with the more moderate estimate of 50,000,000 of years. This would imply at least about 3000° C. for the limiting temperature at great depths. If the actual substance of the earth, whatever it may be, rocky or metallic, at depths of from 60 to 100 kilometers, under the pressure actually there experienced by it can be solid at temperatures of from 3000° to 4000°, then we may hold the former estimate (90,000,000) to be as probable as the latter (50,000,000) so far as evidence from underground temperature can guide us. If 4000° would melt the earth's substance at a depth of 100 kilometers, we must reject the former estimate, though we might still admit the latter; if 3000° would melt the substance at a depth of 60 kilometers, we should be compelled to conclude that 50,000,000 of years is an over-estimate. Whatever may be its age, we may be quite sure the earth is solid in its interior; not, I admit, throughout its whole volume, for there certainly are spaces in

volcanic regions occupied by liquid lava: but whatever portion of the whole mass is liquid, whether the waters of the ocean or melted matter in the interior, these portions are small in comparison with the whole, and we must utterly reject any geological hypothesis which, whether for explaining underground heat or ancient upheavals and subsidences of the solid crust, or earthquakes, or existing volcanoes, assumes the solid earth to be a shell of 30, or 100, or 500, or 1,000 kilometers thickness, resting on an interior liquid mass.

This conclusion was first arrived at by Hopkins, who may therefore properly be called the discoverer of the earth's solidity. He was led to it by a consideration of the phenomena of precession and nutation, and gave it as shown to be highly probable, if not absolutely demonstrated, by his confessedly imperfect and tentative investigation. But a rigorous application of the perfect hydrodynamical equations leads still more decidedly to the same conclusion.

I am able to say this to you now in consequence of the conversation with Professor Newcomb to which I have already alluded. Admitting fully my evidence for the rigidity of the earth from the tides, he doubted the argument from precession and nutation. Trying to recollect what I had written on it fourteen years ago in a paper on the Rigidity of the Earth, published in the *Transactions* of the Royal Society, my conscience smote me, and I could only stammer out that I had convinced myself that so and so, and so and so, at which I had arrived by a non-mathematical short cut, were true. He hinted that viscosity might suffice to render precession and nutation the same as if the earth were rigid, and so vitiate the argument for rigidity. This I could not for a moment admit any more than when it was first put forward by Delaunay. But doubt entered my mind regarding the so and so, and so and so; and I had not completed the night journey to Philadelphia which hurried me away from our unfinished discussion before I had convinced myself that they were grievously wrong. So now I must request as a favor that each one of you on going home will instantly turn up his or her copies of the *Transactions* of the Royal Society for 1862, and of Thomson and Tait's "Natural Philosophy," vol. i., and draw the pen through §§ 23–31 of my paper on the "Rigidity of the Earth" in the former, and through everything in §§ 847–849 of the latter, which refers to the effect on precession and nutation of an elastic yielding of the earth's surface.

When those passages were written I knew little or nothing of vortex motion; and until my attention was recalled to them by Professor Newcomb, I had never once thought of this subject in the light thrown upon it by the theory of the quasi-rigidity

induced in a liquid by vortex motion which has of late occupied me so much. With this fresh light a little consideration sufficed to show me that (although the old obvious conclusion is of course true, that if the inner boundary of the imagined rigid shell of the earth were rigorously spherical, the interior liquid could experience no precessional or nutational influence from the pressure on its bounding surface, and therefore if homogeneous could have no precession or nutation at all, or if heterogeneous only as much precession and nutation as would be produced by attraction from without in virtue of non-sphericity of its surfaces of equal density, and therefore the shell would have enormously more rapid precession and nutation than it actually has—forty times as much, for instance, if the thickness of the shell is sixty kilometers) a very slight deviation of the inner surface of the shell from perfect sphericity would suffice, in virtue of the quasi-rigidity due to vortex motion, to hold back the shell from taking sensibly more precession than it would give to the liquid, and to cause the liquid (homogeneous or heterogeneous) and the shell to have sensibly the same precessional motion as if the whole constituted one rigid body. But it is only because of the very long period (26,000 years) of precession, in comparison with the period of rotation (one day), that a very slight deviation from sphericity would suffice to cause the whole to move as if it were a rigid body. A little further consideration showed me—

(1) That an ellipticity of inner surface equal to $\frac{1}{26000 \times 365}$ would be too small, but that an ellipticity of one or two hundred times this amount would not be too small, to compel approximate equality of precession throughout liquid and shell.

(2) That with an ellipticity of interior surface equal to $\frac{1}{300}$, if the precessional motive were 26,000 times as great as it is, the motion of the liquid would be very different from that of a rigid mass rigidly connected with the shell:

(3) That with the actual forces and the supposed interior ellipticity of $\frac{1}{300}$ the. lunar nineteen-yearly nutation might be affected to about five per cent of its amount by interior liquidity.

(4) Lastly, that the lunar semi-annual nutation must be largely, and the lunar fortnightly nutation enormously, affected by interior liquidity.

But although so much could be foreseen readily enough, I found it impossible to discover, without thorough mathematical investigation, what might be the characters and amounts of the deviations from a rigid body's motion which the several cases of precession and nutation contemplated would present. The investigation, limited to the case of a homogeneous liquid en-

closed in an ellipsoidal shell, has brought out results which I confess have greatly surprised me. When the interior ellipticity of the shell is just too small, or the periodic speed of the disturbance just too great to allow the motion of the whole to be sensibly that of a rigid body, the deviation first sensible renders the precessional or nutational motion of the shell smaller than if the whole were rigid, instead of greater, as I expected. The amount of this difference bears the same proportion to the actual precession or nutation as the fraction measuring the periodic speed of the disturbance (in terms of the period of rotation as unity) bears to the fraction measuring the interior ellipticity of the shell; and it is remarkable that this result is independent of the thickness of the shell, assumed however to be small in proportion to the earth's radius. Thus in the case of precession the effect of interior liquidity would be to diminish the periodic speed of the precession in the proportion stated; in other words, it would add to the precessional period a number of days equal to the multiple of the rotational period equal to the number whose reciprocal measures the ellipticity. Thus in the actual case of the earth if we still take $\frac{1}{300}$ as the ellipticity of the inner boundary of the supposed rigid shell, the effect would be to augment by 300 days the precessional period of 2,600 years, or to diminish by about $\frac{1}{87}''$ the annual precession of about 51″—an effect which I need not say would be wholly insensible. But on the lunar nutation of 18·6 years period the effect of interior liquidity would be quite sensible; 18·6 years being 23 times 300 days, the effect would be to diminish the axes of the ellipse which the earth's pole describes in this period each by $\frac{1}{23}$ of its own amount. The semi-axes of this ellipse calculated on the theory of perfect rigidity from the very accurately known amount of precession and the fairly accurate knowledge which we have of the ratio of the lunar to the solar part of the precessional motive are 9″·22 and 6″·86, with an uncertainty not amounting to one-half per cent on account of want of perfect accuracy in the latter part of data. If the true values were less each by $\frac{1}{23}$ of its own amount, the discrepance might have escaped detection, or might *not* have escaped detection; but certainly could be found if looked for. So far nothing can be considered as absolutely proved with reference to the interior solidity of the earth from precession and nutation; but now think of the solar semi-annual and the lunar fortnightly nutations. The period of each of these is less than 300 days. Now the hydrodynamical theory shows that irrespective of the thickness of the shell, the nutation of the crust would be zero if the period of the nutational disturbance were 300 times the period of rotation (the ellipticity being $\frac{1}{300}$): if the nutational period were anything between

this and a certain smaller critical value depending on the thickness of the crust, the nutation would be negative; if the period were equal to this second critical value, the nutation would be infinite: and if the period were still less, the nutation would be again positive. Further, the 183 days period of the solar nutation falls so little short of the critical 300 days, that the amount of the nutation is not sensibly influenced by the thickness of the crust—is negative and equal in absolute value to $\frac{61}{39}$ (being the reciprocal of $\frac{300}{183}-1$) times what the amount would be were the earth solid throughout. Now this amount as calculated in the Nautical Almanac makes $0''\cdot55$, and $0''\cdot51$ the semi-axes of the ellipse traced by the earth's axis round its mean position; and if the true nutation placed the earth's axis on the opposite side of an ellipse having $''\cdot86$ and $''\cdot81$ for its semi-axes, the discrepance could not possibly have escaped detection. But lastly, think of the lunar fortnightly nutation. Its period is $\frac{1}{22}$ of 300 days, and its amount, calculated in the Nautical Almanac on the theory of complete solidity, is such that the greater semi-axis of the approximately circular ellipse described by the pole is $0''\cdot0325$. Were the crust infinitely thin this nutation would be negative, but its amount nineteen times that corresponding to solidity. This would make the greater semi-axis of the approximately circular ellipse described by the pole amount to $19\times0''\cdot0885$, which is $1''\cdot7$. It would be negative and of some amount between $1''\cdot7$ and infinity, if the thickness of the crust were anything from zero to 120 kilometers. This conclusion is absolutely decisive against the geological hypothesis of a thin rigid shell full of liquid.

But interesting in a dynamical point of view as Hopkin's problem is, it cannot afford a decisive argument against the earth's interior liquidity. It assumes the crust to be perfectly stiff and unyielding in its figure. This of course it cannot be, because no material is infinitely rigid; but, composed of rock and possibly of continuous metal in the great depths, may the crust not as a whole be still enough to practically fulfill the condition of unyieldingness? No; decidedly it could not; on the contrary, were it of continuous steel and 500 kilometers thick, it would yield very nearly as much as if it were india-rubber, to the deforming influences of centrifugal force and of the sun's and moon's attractions. Now, although the full problem of precession and nutation, and what is now necessarily included in it, tides—in a continuous revolving liquid spheroid, whether homogeneous or heterogeneous, has not yet been coherently worked out, I think I see far enough towards a complete solution to say that precession and nutations will be practically the same in it as in a solid globe, and that the tides will be practically the same as those of the equilibrium

theory. From this it follows that precession and nutations of the solid crust, with the practically perfect flexibility which it would have even though it were 100 kilometers thick and as stiff as steel, would be sensibly the same as if the whole earth from surface to center were solid and perfectly stiff. Hence precession and nutations yield nothing to be said against such hypotheses as that of Darwin,* that the earth as a whole takes approximately the figure due to gravity and centrifugal force, because of the fluidity of the interior and the flexibility of the crust. But alas for this "attractive sensational idea that a molten interior to the globe underlies a thin superficial crust; its surface agitated by tidal waves and flowing freely towards any issue that may here and there be opened for its outward escape," as Poulett Scrope called it! the solid crust would yield so freely to the deforming influence of sun and moon that it would simply carry the waters of the ocean up and down with it, and there would be no sensible tidal rise and fall of water relatively to land.

The state of the case is shortly this:—The hypothesis of a perfectly rigid crust containing liquid violates physics by assuming preternaturally rigid matter and violates dynamical astronomy in the solar semi-annual and lunar fortnightly nutations; but tidal theory has nothing to say against it. On the other hand the tides decide against any crust flexible enough to perform the nutations correctly with a liquid interior, or as flexible as the crust must be unless of preternaturally rigid matter.

But now thrice to slay the slain; suppose the earth this moment to be a thin crust of rock or metal resting on liquid matter. Its equilibrium would be unstable! And what of the upheavals and subsidences? They would be strikingly analogous to those of a ship which has been rammed: one portion of crust up and another down, and then all down. I may say with almost perfect certainty, that, whatever may be the relative densities of rock, solid and melted, at or about the temperature of liquifaction, it is, I think, quite certain that cold solid rock is denser than hot melted rock: and no possible degree of rigidity in the crust could prevent it from breaking in pieces and sinking wholly below the liquid lava. Something like this may have gone on and probably did go on for thousands of years after solidification commenced; surface portions of the melted material losing heat, freezing, sinking immediately, or growing to thicknesses of a few meters when the surface would be cool and the whole solid dense enough to sink. "This

* "Observations on the Parallel Roads of Glen Roy and other Parts of Lochaber in Scotland, with an attempt to prove that they are of Marine Origin."—*Transactions* of the Royal Society for Feb., 1839, p. 81.

process must go on until the sunk portions of crust build up from the bottom a sufficiently close-ribbed skeleton or frame, to allow fresh incrustations to remain bridging across the now small areas of lava, pools or lakes.

"In the honey-combed solid and liquid mass thus formed, there must be a continual tendency for the liquid, in consequence of its less specific gravity, to work its way up; whether by masses of solid falling from the roofs of vesicles or tunnels, and causing earthquake shocks, or by the roof breaking quite through when very thin, so as to cause two such hollows to unite or the liquid of any of them to flow out freely over the outer surface of the earth; or by gradual subsidence of the solid owing to the thermodynamic melting, which portions of it under intense stress must experience according to my brother's theory. The results which must follow from this tendency seem sufficiently great and various to account for all that we learn from geological evidence of earthquakes, of upheavals and subsidences of solid, and of eruptions of melted rock."*

Leaving altogether now the hypothesis of a hollow shell filled with liquid, we must still face the question, how much does the earth. solid throughout, except small cavities or vesicles filled with liquid, yield to the deforming (or tide-generating) influences of sun and moon? This question can only be answered by observation. A single infinitely accurate spirit-level or plummet far enough away from the sea to be not sensibly affected by the attraction of the rising and falling water would enable us to find the answer. Observe by level or plummet the changes of direction of apparent gravity relatively to an object rigidly connected with the earth, and compare these changes with what they would be were the earth perfectly rigid, according to the known masses and distances of sun and moon. The discrepance. if any is found, would show distortion of the earth and would afford data for determining the dimensions of the elliptic spheroid into which a non-rotating globular mass of the same dimensions and elasticity as the earth would be distorted by centrifugal force if set in rotation, or by the tide-generating influence of sun or moon. The effect on the plumb-line of the lunar tide-generating influence is to deflect it towards or from the point of the horizon nearest to the moon, according as the moon is above or below the horizon. The effect is zero when the moon is on the horizon or overhead, and is greatest in either direction when the moon is 45° above or below the horizon. When this greatest value is reached. the plummet is drawn from its mean position through

* "Secular Cooling of the Earth." *Transactions* of the Royal Society of Edinburgh, 1862 (W. Thomson), and Thomson and Tait's "Natural Philosophy," §§ (*e e*), (*f f*).

a space equal to $\frac{1}{12000000}$ of the length of the thread. No ordinary plummet or spirit-level could give any perceptible indication whatever of this effect: and to measure its amount it would be necessary to be able to observe angles as small as $\frac{1}{120000000}$ of the radius, or about $\frac{1}{600}''$. Siemens' beautiful hydrostatical multiplying level may probably supply the means for doing this. Otherwise at present no apparatus exists within small compass by which it could be done. A submerged water-pipe of considerable length, say twelve kilometers, with its two ends turned up and open might answer. Suppose, for example, the tube to lie North and South, and its two ends to open into two small cisterns, one of them, the southern, for example, of half a decimeter diameter (to escape disturbance from capillary attraction): and the other of two or three decimeters diameter (so as to throw nearly the whole rise and fall into the smaller cistern). For simplicity suppose the time of observation to be when the moon's declination is zero. The water in the smaller or southern cistern will rise from its lowest position to its highest position while the moon is rising to maximum altitude, and fall again after the moon crosses the meridian till she sets: and it will rise and fall again through the same range from moonset to moonrise. If the earth were perfectly rigid, and if the locality were in latitude 45°, the rise and fall would be half a millimeter on each side of the mean level; or a little short of half a millimeter if the place is within 10° north or south of latitude 45°. If the air were so absolutely quiescent during the observatione as to give no varying differential pressure on the two water surfaces to the amount of $\frac{1}{100}$ millimetre of water, or $\frac{1}{1400}$ of mercury, the observation would be satisfactorily practicable, as it would not be difficult by aid of a microscope to observe the rise and fall of the water in the smaller cistern to $\frac{1}{100}$ of a millimeter; but no such quiescence of the atmosphere could be expected at any time, and it is probable that the variations of the water-level due to difference of the barometric pressure at the two ends would in all ordinary weather quite overpower the small effect of the lunar tide-generating motive. If, however, the two cisterns instead of being open to the atmosphere were connected air-tightly by a return pipe with no water in it, it is probable that the observation might be successfully made: but Siemens' level or some other apparatus on similarly small scale would probably be preferable to any elaborate method of obtaining the result by aid of very long pipes laid in the ground; and I have only called your attention to such an ideal method as leading up to the natural phenomenon of tides.

Tides in an open canal or lake of twelve kilometers length would be of just the amount which we have estimated for the cisterns connected by submerged pipe; but would be enor-

mously more disturbed by wind and variations of atmospheric pressure. A canal or lake of 240 kilometers length, in a proper direction in a suitable locality, would give but ten millimeters rise and fall at each end, an effect which might probably be analyzed out of the much greater disturbance produced by wind and differences of barometric pressure; but no open liquid level short of the *ingens æquor*, the ocean, will probably be found so well adapted as it for measuring the absolute value of the disturbance produced on terrestrial gravity by the lunar and solar tide-generating motive. But observations of the diurnal and semi-diurnal tides in the ocean, do not (as they would on smaller and quicker levels) suffice for this purpose, because their amounts differ enormously from the equilibrium values on account of the smallness of their periods in comparison with the periods of any of the grave enough modes of free vibration of the ocean as a whole. On the other hand the lunar fortnightly declinational and the lunar monthly elliptic and the solar semi-annual and annual elliptic tides have their periods so long that their amounts must certainly be very approximately equal to the equilibrium values.

But there are large annual and semi-annual changes of sea-level, probably both differential on account of wind and differences of barometric pressure and differences of temperature of the water, and absolute depending on rain-fall and the melting away of snow and return evaporation, which altogether swamp the small semi-annual and annual tides due to the sun's attraction. Happily, however, for our object there is no meteorological or other disturbing cause which produces periodic changes of sea-level in either the fortnightly declinational or the monthly elliptic period; and the lunar gravitational tides in these periods are therefore to be carefully investigated in order that we may obtain the answer to the interesting question, how much does the earth as an elastic spheroid yield to the tide-generating influence of sun or moon? Hitherto in the British Association Committee's reductions of Tidal Observations we have not succeeded in obtaining any trustworthy indications of either of these tides. The St. George's pier landing-stage pontoon was unhappily chosen, for the Liverpool tide gauge cannot be trusted for so delicate an investigation; the available funds for calculation were expended before the long-period tides for Helbre Island could be attacked, and three years of Kurrachee gave our only approach to a result. Comparisons of this, with an indication of a result with calculations on West Hartlepool tides, conducted with the assistance of a grant from the Royal Society, seem to show possibly no sensible yielding, or perhaps, more probably some degree of yielding, of the earth's figure. The absence from all the results of any indication of a 18·6

yearly tide (according to the same law as the other long-period tides) is not easily explained without assuming or admitting a considerable degree of yielding.

Closely connected with the question of the earth's rigidity, and of as great scientific interest and even of greater practical moment, is the question—how nearly accurate is the earth as a time-keeper? and another of, at all events, equal scientific interest—how about the permanence of the earth's axis of rotation?

Peters and Maxwell, about thirty-five and twenty-five years ago, separately raised the question, how much does the earth's axis of rotation deviate from being a principal axis of inertia? and pointed out that an answer to this question is to be obtained by looking for a variation in latitude of any or every place on the earth's surface in a period of 306 days. The model before you illustrates the travelling round of the instantaneous axis relatively to the earth in an approximately circular cone whose axis is the principal axis of inertia, and relatively to space in a cone round a fixed axis. In the model, the former of these cones, fixed relatively to the earth, rolls internally on the latter, supposed to be fixed in space. Peters gave a minute investigation of observations at Pulkova in the years 1841-42, which seemed to indicate at that time a deviation amounting to about $\frac{3}{10}''$ of the axis of rotation from the principal axis. Maxwell, from Greenwich observations of the years 1851-1854, found seeming indications of a very slight deviation—something less than half a second—but differing altogether in phase from that which the deviation indicated by Peters, if real and permanent, would have produced at Maxwell's later time. On my begging Prof. Newcomb to take up the subject, he kindly did so at once, and undertook to analyze a series of observations suitable for the purpose, which had been made in the United States Naval Observatory, Washington. A few weeks later I received from him a letter referring me to a paper by Dr. Nysen, of Pulkova Observatory, in which a similar negative conclusion as to constancy of magnitude or direction in the deviation sought for is arrived at from several series of the Pulkova observations between the years 1842 and 1872, and containing the following statement of his conclusions:—

"The investigation of the ten month period of latitude from the Washington prime vertical observations from 1862 to 1867 is completed, indicating a coefficient too small to be measured with certainty. The declinations with this instrument are subject to an annual period which made it necessary to discuss those of each month separately. As the series extended through a full five years, each month thus fell on five nearly equidistant

points of the period. If x and y represent the co-ordinates of the axis of instantaneous rotation on June 30, 1864, then the observations of the separate months gave the following values of x and y:—

	x ″		Weight.		y ″	Weight.
January ..	− 0·35	...	10	...	+ 0·32	
February ..	− 0·03	...	14	...	+ 0·09	
March ..	+ 0·17	...	10	...	+ 0·16	
April	+ 0·44	...	5	...	+ 0·05	
May	+ 0·08	...	16	...	+ 0·02	
June	− 0·01	...	14	...	− 0·01	
July	− 0·05	...	14	...	− 0·00	
August ..	− 0·24	...	14	...	+ 0·29	
September ..	+ 0·18	...	14	...	+ 0·21	
October ..	+ 0·13	...	14	...	− 0·01	
November ..	+ 0·08	...	17	...	− 0·20	
December ..	− 0·08	...	16	...	− 0·08	
Mean	0″·01±″·03				+ 0″·05±″·03	

Accepting these results as real they would indicate a radius of rotation of the instantaneous axis amounting, at the earth's surface, to 5 feet and a longitude of the point in which this axis intersects the earth's surface near the north pole such that on July 11, 1864, it was 180° from Washington, or 103° east of Greenwich. The excess of the co-efficient over its probable error is so slight that this result cannot be accepted as anything more than a consequence of the unavoidable errors of observation."

From the discordant character of these results we must not, however, infer that the deviations indicated by Peters, Maxwell, and Newcomb are unreal. On the contrary, any that fall within the limits of probable error of the observations ought properly to be regarded as real. There is in fact a *vera causa* in the temporary changes of sea-level due to meteorological causes, chiefly winds, and to meltings of ice in the polar regions and return evaporations, which seems amply sufficient to account for irregular deviations of from $\frac{1}{2}''$ to $\frac{1}{20}''$ of the earth's instantaneous axis from the axis of maximum inertia, or, as I ought rather to say, of the axis of maximum inertia from the instantaneous axis.

As for geological upheavals and subsidences, if on a very large scale of area, they must produce, on the period and axis of the earth's rotation, effects comparable with those produced by changes of sea-level equal to them in vertical amount. For simplicity, calculating as if the earth were of equal density throughout, I find that an upheaval of all the earth's surface in

north latitude and east longitude, and south latitude and west longitude, with equal depressions in the other two quarters, amounting at greatest to 10 centimeters, and graduating regularly from the points of maximum elevation to the points of maximum depression in the middles of the four quarters, would shift the earth's axis of maximum moment of inertia through $1''$ on the north side towards the meridian of $90°$ W. longitude, and on the south side towards the meridian of $90°$ E. longitude. If such a change were to take place suddenly, the earth's instantaneous axis would experience a sudden shifting of but $\frac{1}{306}''$ (which we may neglect) and then, relatively to the earth, would commence traveling, in a period of 306 days, round the fresh axis of maximum moment of inertia. The sea would be set into vibration, one ocean up and another down through a few centimeters, like water in a bath set aswing. The period of these vibrations would be from twelve to twenty-four hours, or at most a day or two; their subsidence would probably be so rapid that after at most a few months they would become insensible. Then a regular 306 days' period tide of 11 centimeters from lowest to highest would be to be observed, with gradually diminishing amount from century to century, as though the dissipation of energy produced by this tide, the instantaneous axis of the earth is gradually brought into coincidence with the fresh axis of maximum moment of inertia. If we multiply these figures by 3,600, we find what would be the result of a similar sudden upheaval and subsidence of the earth to the extent of 360 meters above and below previous levels. It is not impossible that in the very early ages of geological history such an action as this, and the consequent 400 meters tide producing a succession of deluges every 306 days for many years may have taken place: but it seems more probable that even in the most ancient times of geological history the great world-wide changes, such as the upheavals of the continents and subsidences of the ocean beds from the general level of their supposed molten origin, took place gradually through the thermodynamic melting of solids and the squeezing out of liquid lava from the interior to which I have already referred. A slow distortion of the earth as a whole would never produce any great angular separation between the instantaneous axis and axis of maximum moment of inertia for the time being. Considering, then, the great facts of the Himalayas and Andes, and Africa and the depths of the Atlantic, and America and the depths of the Pacific, and Australia, and considering further the ellipticity of the equatorial section of the sea-level estimated by Capt. Clarke at about $\frac{1}{10}$ of the mean ellipticity of meridianal sections of the sea-level, we need no brush from the comet's tail, a wholly chimerical cause which can never have

been put forward seriously except in ignorance of elementary dynamical principles, to account for a change in the earth's axis; we need no violent convulsion producing a sudden distortion on a great scale with change of the axis of maximum moment of inertia followed by gigantic deluges; and we may not merely admit, but assert as highly probable, that the axis of maximum inertia and axis of rotation, always very near one another, may have been in ancient times very far from their present geographical position, and may have gradually shifted through ten, twenty, thirty, forty, or more degrees without, at any time, any perceptible sudden disturbance of either land or water.

Lastly, as to variations in the earth's rotational period:—You all, no doubt, know how in 1853 Adams discovered a correction to be needed in the theoretical calculation with which Laplace followed up his brilliant discovery of the dynamical explanation of an apparent acceleration of the moon's mean motion, shown by records of ancient eclipses; and how he found that when his correction was applied, the dynamical theory of the moon's motion accounted for only about half of the observed apparent acceleration; and how Delauney in 1866 verified Adams's result, and suggested that the explanation may be a retardation of the earth's rotation by tidal friction. The conclusion is that since March 19, 721 B. C., a day on which an eclipse of the moon was seen in Babylon, commencing "when one hour after her rising was fully passed," the earth has lost rather more than $\frac{1}{3600000}$ of her rotational velocity, or as a timekeeper, is going slower by $11\frac{1}{2}$ seconds per annum now than then. According to this rate of retardation, if uniform, the earth at the end of a century would, as a timekeeper, be found 22 seconds behind a perfect clock, rated and set to agree with her at the beginning of the century. Newcomb's subsequent investigations in the lunar theory have on the whole tended to confirm this result, but they have also brought to light some remarkable apparent irregularities in the moon's motion, which, if real, refuse to be accounted for by the gravitational theory without the influence of some unseen body or bodies passing near enough to the moon to influence her mean motion. This hypothesis Newcomb considers not so probable as that the apparent irregularities of the moon are not real and are to be accounted for by irregularities in the earth's rotational velocity. If this is the true explanation it seems that the earth was going slow from 1850 to 1862, so much as to have got behind 7 seconds in these 12 years, and then to have begun going faster again so as to gain 8 seconds from 1862 to 1872. So great an irregularity as this would require somewhat greater changes of sea-level, but not many times greater, than the British Association Commit-

tee's reductions of tidal observations for several places in different parts of the world, allow us to admit to have possibly taken place. The assumption of a fluid interior, which Newcomb suggests, and the flow of a large mass of the fluid "from equatorial regions to a position nearer the axis," is not, from what I have said to you, admissible as a probable explanation of the remarkable acceleration of rotational velocity which seems to have taken place about 1862; but happily it is not necessary. A settlement of 14 centimeters in the equatorial regions with corresponding rise of 28 centimeters at the poles, which is so slight as to be absolutely undiscoverable in astronomical observatories, and which would involve no change of sea-level absolutely disproved by reductions of tidal observations hitherto made would suffice. Such settlements must occur from time to time; and a settlement of the amount suggested might result from the diminution of centrifugal force due to 150 or 200 centuries' tidal retardation of the earth's rotational speed.

ART. LXII.—*Address at the Glasgow Meeting of the British Association, by* ALFRED RUSSEL WALLACE, President of the Section of Biology.

Introduction.

THE range of subjects comprehended within this Section is so wide, and my own acquaintance with them so imperfect and fragmentary, that it is not in my power to lay before you any general outline of the recent progress of the biological sciences. Neither do I feel competent to give you a summary of the present status of any one of the great divisions of our science—such as Anatomy, Physiology, Embryology, Histology, Classification, or Evolution—Philology, Ethnology, or Prehistoric Archæology; but there are fortunately several outlying and more or less neglected subjects to which I have for some time had my attention directed, and which I hope will furnish matter for a few observations, of some interest to biologists, and at the same time not unintelligible to the less scientific members of the Association who may honor us with their presence.

The subjects I first propose to consider have no general name, and are not easily grouped under a single descriptive heading; but they may be compared with that recent development of a sister-science, which has been termed Surface-geology, or Earth-sculpture. In the older geological works we learnt much about strata, and rocks, and fossils, their superposition, contortions, chemical constitution, and affinities, with some general notions of how they are formed in the remote past; but we often came

to the end of the volume no whit the wiser as to how and why the surface of the earth came to be so wonderfully and beautifully diversified; we were not told why some mountains are rounded and others precipitous; why some valleys are wide and open, others narrow and rocky; why rivers so often pierce through mountain-chains; why mountain lakes are often so enormously deep; whence came the gravel, and drift, and erratic blocks, so strangely spread over wide areas while totally absent from the other areas equally extensive. So long as these questions were almost ignored, geology could hardly claim to be a complete science, because, while professing to explain how the crust of the earth came to be what it is, it gave no intelligible account of the varied phenomena presented by its surface. But of late years these surface-phenomena have been assiduously studied; the marvellous effects of denudation and glacial action in giving the final touches to the actual contour of the earth's surface, and their relation to climatic changes and the antiquity of man, have been clearly traced, thus investing geology with a new and popular interest, and at the same time elucidating many of the phenomena presented in the older formations.

Now, just as a surface-geology was required to complete that science, so a surface-biology was wanted to make the science of living things more complete and more generally interesting, by applying the results arrived at by special workers, to the interpretation of those external and prominent features whose endless variety and beauty constitute the charm which attracts us to the contemplation or to the study of nature. We have the descriptive zoologist, for example, who gives us the external characters of animals; the anatomist studies their internal structure; the histologist makes known the nature of their component tissues; the embryologist patiently watches the progress of their development; the systematist groups them into classes and orders, families, genera, and species; while the field-naturalist studies for us their food and habits and general economy. But till quite recently, none of these earnest students, nor all of them combined, could answer satisfactorily, or ever attempted to answer, many of the simplest questions concerning the external characters and general relations of animals and plants. Why are flowers so wonderfully varied in form and color? What causes the Arctic fox and the ptarmigan to turn white in winter? Why are there no elephants in America and no deer in Australia? Why are closely allied species rarely found together? Why are male animals so frequently bright colored? Why are extinct animals so often larger than those which are now living? What has led to the production of the gorgeous train of the peacock and of the two kinds of flower in the primrose? The solution

of these and a hundred other problems of like nature, was rarely approached by the old method of study, or if approached was only the subject of vague speculation. It is to the illustrious author of the "Origin of Species" that we are indebted, for teaching us how to study nature as one great, compact, and beautifully adjusted system. Under the touch of his magic wand the countless isolated facts of internal and external structure of living things—their habits, their colors, their development, their distribution, their geological history,—all fell into their approximate places; and although, from the intricacy of the subject and our very imperfect knowledge of the facts themselves, much still remains uncertain; yet we can no longer doubt that even the minutest and most superficial peculiarities of animals and plants either, on the one hand, are or have been useful to them, or, on the other hand, have been developed under the influence of general laws, which we may one day understand to a much greater extent than we do at present. So great is the alteration effected in our comprehension of nature by the study of variation, inheritance, cross-breeding, competition, distribution, protection, and selection—showing, as they often do, the meaning of the most obscure phenomena, and the mutual dependence of the most widely-separated organisms, that it can only be fitly compared with the analogous alteration produced in our conception of the universe by Newton's grand discovery of the law of gravitation.

I know it will be said (and is said), that Darwin is too highly rated; that some of his theories are wholly and others partially erroneous, and that he often builds a vast superstructure on a very uncertain basis of doubtfully interpreted facts. Now, even admitting this criticism to be well founded—and I myself believe that to a limited extent it is so—I nevertheless maintain that Darwin is not and cannot be too highly rated. For his greatness does not all depend upon his being infallible, but on his having developed, with rare patience and judgment, a new system of observation and study, guided by certain general principles which are almost as simple as gravitation, and as wide-reaching in their effects. And if other principles should hereafter be discovered, or if it be proved that some of his subsidiary theories are wholly or partially erroneous, this very discovery can only be made by following in Darwin's steps, by adopting the method of research which he has taught us, and by largely using the rich stores of material which he has collected. The "Origin of Species," and the grand series of works which have succeeded it, have revolutionized the study of biology. They have given us new ideas and fertile principles. They have infused life and vigor into our science, and have opened up hitherto unthought of lines of research on which

hundreds of eager students are now laboring. Whatever modifications some of his theories may require, Darwin must none the less be looked up to as the founder of philosophical biology.

As a small contribution to this great subject, I propose now to call your attention to some curious relations of organisms to their environment, which seem to me worthy of more systematic study than has hitherto been given them. The points I shall more especially deal with are—the influence of locality, or of some unknown local causes, in determining the colors of insects and, to a less extent, of birds: and the way in which certain peculiarities in the distribution of plants may have been brought about by their dependence on insects. The latter part of my address will deal with the present state of our knowledge as to the antiquity and early history of mankind.

2. *On some Relations of Living Things to their Environment.*

Of all the external characters of animals, the most beautiful, the most varied, and the most generally attractive, are the brilliant colors and strange yet often elegant markings with which so many of them are adorned. Yet, of all characters, this is the most difficult to bring under the laws of utility or of physical connection. Mr. Darwin—as you are well aware—has shown how wide is the influence of sex on the intensity of coloration; and he has been led to the conclusion that active or voluntary sexual selection is one of the chief causes, if not the chief cause, of all the variety and beauty of color we see among the higher animals. This is one of the points on which there is much divergence of opinion even among the supporters of Mr. Darwin, and one as to which I myself differ from him. I have argued, and still believe, that the need of protection is a far more efficient cause of variation of color than is generally suspected: but there are evidently other causes at work, and one of these seems to be an influence depending strictly on locality, whose nature we cannot yet understand, but whose effects are everywhere to be seen when carefully searched for.

Although the careful experiments of Sir John Lubbock have shown that insects can distinguish colors—as might have been inferred from the brilliant colors of the flowers which are such an attraction to them—yet we can hardly believe that their appreciation and love of distinctive colors is so refined as to guide and regulate their most powerful instinct—that of reproduction. We are therefore led to seek some other cause for the varied colors that prevail among insects; and as this variety is most conspicuous among butterflies,—a group perhaps better known than any other—it offers the best means of studying the subject. The variety of color and marking among these insects is something marvellous. There are probably about ten thousand

different kinds of butterflies now known, and about half of these are so distinct in color and marking that they can be readily distinguished by this means alone. Almost every conceivable tint and pattern is represented, and the hues are often of such intense brilliance and purity as can be equalled by neither birds nor flowers.

Any help to a comprehension of the causes which may have concurred in bringing about so much diversity and beauty must be of value, and this is my excuse for laying before you the more important cases I have met with of a connection between color and locality.

Our first example is from tropical Africa, where we find two unrelated groups of butterflies belonging to two very distinct families (Nymphalidæ and Papilionidæ) characterized by a prevailing blue green color not found in any other continent.* Again, we have a group of African Pieridæ which are white or pale yellow with a marginal row of bead-like black spots, and in the same country one of the Lycænidæ (*Liptena erastus*) is colored so exactly like these that it was at first described as a species of *Pieris.* None of these four groups are known to be in any way specially protected so that the resemblance cannot be due to protective mimicry.

In South America we have far more striking cases. For in the three sub-families— Danainæ, Acræniæ, and Heliconiinæ— all of which are specially protected, we find identical tints and patterns reproduced, often in the greatest detail, each peculiar type of coloration being characteristic of distinct geographical subdivisions of the continent. Nine very distinct genera are implicated in these parallel changes—*Lycorea*, *Ceratinia*, *Mechanitis*, *Ithomia*, *Melinœa*, *Tithorea*, *Acrœa*, *Heliconius*, and *Eueides* —groups of three or four (or even of five) of them appearing together in the same livery in one district, while in an adjoining district most or all of them undergo a simultaneous change of coloration or of marking. Thus in the genera *Ithomia*, *Mechanitis*, and *Heliconius*, we have species with yellow apical spots in Guiana, all represented by allied species with white apical spots in South Brazil. In *Mechanitis*, *Melinœa*, and *Heliconius*, and sometimes in *Tithorea*, the species of the Southern Andes (Bolivia and Peru) are characterized by an orange and black livery, while those of the Northern Andes (New Grenada) are almost always orange-yellow and black. Other changes of a like nature, which it would be tedious to enumerate, but which are very striking when specimens are examined, occur in species of the same groups inhabiting these same localities, as well as Central America and the Antilles. The resemblance thus pro-

* *Romaleosoma Euryphene* (Nymphalidæ), *Papilio zalmoxis*, and several species of the *Nireus* group (Papilionidæ).

duced between widely different insects is sometimes general, but often so close and minute that only a critical examination of structure can detect the difference between them. Yet this can hardly be true mimicry, because all are alike protected by the nauseous secretion which renders them unpalatable to birds.

In another series of genera (*Catagramma*, *Callithea*, and *Agrias*), all belonging to the Nymphalidæ, we have the most vivid blue ground, with broad bands of orange-crimson or a different tint of blue or purple, exactly reproduced in corresponding, yet unrelated species, occurring in the same locality; yet, as none of these groups are protected, this can hardly be true mimicry. A few species of two other genera in the same country (*Eunice* and *Siderone*) also reproduce the same colors, but with only a general resemblance in the marking. Yet again, in Tropical America we have species of *Apatura* which, sometimes in both sexes, sometimes in the female only, exactly imitate the peculiar markings of another genus (*Heterochroa*) confined to America. Here, again, neither genus is protected, and the similarity must be due to unknown local causes.

But it is among islands that we find some of the most striking examples of the influence of locality on color, generally in the direction of paler, but sometimes of darker and more brilliant hues, and often accompanied by an unusual increase of size. Thus, in the Moluccas and New Guinea we have several Papilios (*P. euchenor*, *P. ormenus*, and *P. tydeus*), distinguished from their allies by a much paler color, especially in the females, which are almost white. Many species of *Danais* (forming the sub-genus *Iedopsis*) also very pale. But the most curious are the Euplœas, which, in the larger islands, are usually of rich dark colors, while in the small islands of Banda, Ké, and Matabello at least three species not nearly related to each other (*E. Hoppferi*, *E. euripon*, and *E. assimilata*) are all broadley banded or suffused with white, their allies in the larger islands being all very much darker. Again, in the genus *Diadema*, belonging to a distinct family, three species from the small Aru and Ké islands (*D. deois*, *D. Hewitsonii*, and *D. polymena*) are all more conspicuously white-marked than their representatives in the larger islands. In the beautiful genus *Cethosia*, a species from the small island of Waigiou (*C. cyrene*), is the whitest of the genus. *Prothoe* is represented by a blue species in the continental island of Java, while those inhabiting the ancient insular groups of the Moluccas and New Guinea are all pale yellow or white. The genus *Drusilla*, almost confined to these islands, comprises many species which are all very pale; while in the small island of Waigiou is found a very distinct genus, *Hyantis*, which, though differing completely in the neuration of the wings, has exactly the same pale

colors and large ocellated spots as *Drusilla.* Equally remarkable is the fact that the small island of Amboina produces larger-sized butterflies than any of the larger islands which surround it. This is the case with at least a dozen butterflies belonging to many distinct genera,* so that it is impossible to attribute it to other than some local influence. In Celebes, as I have elsewhere pointed out,† we have a peculiar form of wing and much larger size running through a whole series of distinct butterflies, and this seems to take the place of any specialty in color.

From the Fiji Islands we have comparatively few butterflies, but there are several species of *Diadema* of unusually pale colors, some almost white.

The Philipine Islands seem to have the peculiarity of developing metallic colors. We find there at least three species of *Euplœa*‡ not closely related, and all of more intense metallic luster than their allies in other islands. Here also we have one of the large yellow Ornithopteræ (*O. Magellanus*), whose hind wings glow with an intense opaline luster not found in any other species of the entire group; and an *Adolias*§ is larger and of more brilliant metallic coloring than any other species in the Archipelago. In these islands also we find the extensive and wonderful genus of weevils, *Pachyrhynchus*, which in their brilliant metallic coloring surpass anything found in the whole eastern hemisphere, if not in the whole world.

In the Andaman Islands, in the Bay of Bengal, there are a considerable number of peculiar species of butterflies differing slightly from those on the continent, and generally in the direction of paler or more conspicuous coloring. Thus, two species of *Papilio*, which on the continent have the tails black, in their Andaman representatives have them either red or white-tipped.‖ Another species** is richly blue-banded where its allies are black; while three species of distinct genera of Nymphalidæ†† all differ from their allies on the continent in being of excessively pale colors, as well as of somewhat larger size.

In Madagascar we have the very large and singularly white-spotted *Papilio antenor*, while species of three other genera‡‡ are very white or conspicuous, compared with their continental allies.

* *Ornithoptera priamus, O. helena, Papilio deiphobus, P. Ulysses, P. Gambrisuis, P. codrus, Iphias leucippe, Euplœa prothöe, Hestia idea, Athyma jocaste, Diadema pandarus, Nymphalis pyrrhus, N. euryalus, Drusilla jairus.*

† "Contributions to the Theory of Natural Selection," pp. 168–173.

‡ *Euplœa Hewitsonii, E. Diocletiana, E. lætifica, E. dupesnii.*

§ *Adolias calliphorus.*

‖ *Papilio rhodifer* (near *P. Doubledayi*) and *Papilio charicles* (near *P. memnon*).

** *Papilio mayo.*

†† *Euplœa Andamanensis, Cethosia biblis, Cyrestis cocles.*

‡‡ *Danais nossima, Melanitis massoura, Diadema dexithea.*

Passing to the West Indian Islands and Central America (which latter country has formed a group of islands in very recent times), we have similar indications. One of the largest of the Papilios inhabits Jamaica,* while another, the largest of its group, is found in Mexico.† Cuba has two of the same fine genus, whose colors are of surpassing brilliancy;‡ while the genus *Clothilda*—confined to the Antilles and Central America—is remarkable for its rich and showy coloring.

Persons who are not acquainted with the important structural differences that distinguish these various genera of butterflies, can hardly realize the importance and the significance of such facts as I have now detailed. It may be well, therefore, to illustrate them by supposing parallel cases to occur among the mammalia. We might have, for example, in Africa, the gnus, the elands, and the buffaloes all colored and marked like zebras, stripe for stripe over the whole body exactly corresponding. So the hares, marmots, and squirrels of Europe might be all red, with black feet, while the corresponding species of Central Asia were all yellow, with black heads. In North America we might have raccoons, squirrels, and opossums in parti-colored livery of white and black, so as exactly to resemble the skunk of the same country; while in South America they might be black, with a yellow throat patch, so as to resemble with equal closeness the tayra of the Brazilian forests. Were such resemblances to occur in anything like the number, and with the wonderful accuracy of imitation met with among the Lepidoptera, they would certainly attract universal attention among naturalists, and would lead to the exhaustive study of the influence of local causes in producing such startling results.

One somewhat similar case does indeed occur among the mammalia, two singular African animals, the Aard-wolf (*Proteles*) and the Hyæna-dog (*Lycaon*), both strikingly resembling hyænas in their general form as well as in their spotted markings. Belonging as they all do to the Carnivora, though to three distinct families, it seems quite an analogous case to those we have imagined; but as the Aard-wolf and the hyæna-dog are both weak animals compared with the hyæna, the resemblance may be useful, and in that case would come under the head of mimicry. This seems the more probable because, as a rule, the colors of the Mammalia are protective, and are too little varied to allow of the influence of local causes producing any well-marked effects.

When we come to the birds, however, the case is different; for although they do not exhibit such distinct marks of the influence of locality as do butterflies—probably because the causes

* *Papilio Homerus.* † *P. daunus.* ‡ *P. Gundlachianus, P. Villiersi.*

which determine color are in their case more complex—yet there are distinct indications of some effect of the kind, and we must devote some little time to their consideration.

One of the most curious cases is that of the parrots of the West Indian Islands and Central America, several of which have white heads or foreheads, occurring in two distinct genera,* while none of the more numerous parrots of South America are so colored. In the small island of Dominica we have a very large and richly-colored parrot (*Chrysotis augusta*) corresponding to the large and richly-colored *Papilio homerus* of Jamaica.

The Andaman Islands are equally remarkable, at least six of the peculiar birds differing from their continental allies in being much lighter, and sometimes with a large quantity of pure white in the plumage,† exactly corresponding to what occurs among the butterflies.

In the Philipines this is not so marked a feature,—yet we have here the only known white-breasted Kingcrow (*Dicrurus mirabilis*),—the newly discovered *Eurylæmus Steerii*, wholly white beneath,—three species of *Diceum*, all white beneath,—several species of *Parus*, largely white-spotted,—while many of the pigeons have light ashy tints. The birds generally, however, have rich-dark colors, similar to those which prevail among the butterflies.

In Celebes we have a swallow-shrike and a peculiar small crow allied to the jackdaw,‡ whiter than any of their allies in the surrounding islands, but otherwise the colors of the birds call for no special remark.

In Timor and Flores we have white-headed pigeons,§ and a long-tailed flycatcher almost entirely white.‖

In the small Lord Howe's Island we have the recently extinct white rail (*Notornis alba*), remarkably contrasting with its allies in the larger islands in New Zealand.

We cannot, however lay any stress on isolated examples of white colors, since these occur in most of the great continents, but where we find a series of species of distinct genera, all differing from their continental allies in a whiter coloration, as in the Andaman Islands and the West Indies; and among butterflies, in the smaller Moluccas, the Andamans, and Madagascar, we cannot avoid the conclusion that in these insular localities some general cause is at work.

There are other cases, however, in which local influences seem to favor the production of preservation of intense crimson

* *Pionus albifrons* and *Chrysotis senilis* (C. America), *Chrysotis Sallæi* (Hayti).

† *Kittacincla albiventris*, *Geocichla albigularis*, *Sturnia Andamanensis*, *Hyloterpe grisola*, *var.*, *Fanthænas palumboides*, *Osmotreron chloroptera.*

‡ *Artamus monachus*, *Corvus advena.*

§ *Ptilopus cinctus*, *P. albocinctus.*

‖ *Tchiterea affinis*, *var.*

or a very dark coloration. Thus in the Moluccas and New Guinea alone we have bright red parrots belonging to two distinct families,* and which, therefore, most probably have been independently produced or preserved by some common cause. Here too and in Australia we have black parrots and pigeons;† and it is a most curious and suggestive fact that in another insular sub-region—that of Madagascar and the Mascarene Islands—these same colors reappear in the same two groups.‡

Some very curious physiological facts bearing upon the presence or absence of white colors in the higher animals have lately been adduced by Dr. Ogle.§ It has been found that a colored or dark pigment in the olfactory region of the nostrils is essential to perfect smell, and this pigment is rarely deficient except when the whole animal is purely white. In these cases the creature is almost without smell or taste. This, Dr. Ogle believes, explains the curious case of the pigs in Virginia adduced by Mr. Darwin, white pigs being poisoned by a poisonous root which does not affect black pigs. Mr. Darwin imputed this to a constitutional difference accompanying the dark color, which rendered what was poisonous to the white-colored animals quite innocuous to the black. Dr. Ogle, however, observes, that there is no proof that the black pigs eat the root, and he believes the more probable explanation to be that it is distasteful to them, while the white pigs, being deficient in smell and taste, eat it and are killed. Analogous facts occur in several distinct families. White sheep are killed in the Tarentino by eating *Hypericum criscum*, while black sheep escape; white rhinoceroses are said to perish from eating *Euphorbia candelabrum*; and white horses are said to suffer from poisonous food where colored ones escape. Now it is very improbable that a constitutional immunity from poisoning by so many distinct plants should in the case of such widely different animals be always correlated with the same difference of color; but the facts are readily understood if the senses of smell and taste are dependent on the presence of a pigment which is deficient in wholly white animals. The explanation has however, been carried a step further, by experiments showing that the absorption of odor by dead matter, such as clothing, is greatly affected by color, black being the most powerful absorbent, then blue, red, yellow, and lastly white. We have here a physical cause for the sense-inferiority of totally white animals which may account for their rarity in nature. For few, if any, wild animals are wholly white. The head, the face, or

* *Lorius*, *Eos* (Trichoglossidæ), *Eclectus* (Palæornithidæ).
† *Microglossus*, *Calyptorhynchus*, *Turacœna*.
‡ *Coracopsis*, *Alectrœnas*.
§ Medico-Chirurgical Transactions, vol. liii, (1870).

at least the muzzle or the nose, are generally black. The ears and eyes are also often black; and there is reason to believe that dark pigment is essential to good hearing, as it certainly is to perfect vision. We can therefore understand why white cats with blue eyes are so often deaf—a peculiarity we notice more readily than their deficiency of smell or taste.

If then the prevalence of white coloration is generally accompanied with some deficiency in the acuteness of the most important senses, the color becomes doubly dangerous, for it not only renders its possessors more conspicuous to its enemies, but at the same time makes it less ready in detecting the presence of danger. Hence, perhaps, the reason why white appears more frequently in islands where competition is less severe and enemies less numerous and varied. Hence, also, a reason why *albinoism*, although freely occurring in captivity never maintains itself in a wild state, while *melanism* does. The peculiarity of some islands in having all their inhabitants of dusky colors—as the Galapagos—may also perhaps be explained on the same principles, for poisonous fruits or seeds may there abound which weed out all white or light-colored varieties, owing to their deficiency of smell and taste. We can hardly believe, however, that this would apply to white-colored butterflies, and this may be a reason why the effect of an insular habitat is more marked in these insects than in birds or mammals. But though inapplicable to the lower animals, this curious relation of sense-acuteness with colors may have had some influence on the development of the higher human races. If light tints of the skin were generally accompanied by some deficiency in the sense of smell, hearing, and vision, the white could never compete with the darker races, so long as man was in a very low or savage condition, and wholly dependent for existence on the acuteness of his senses. But as the mental faculties became more fully developed and more important to his welfare than mere sense-acuteness, the lighter tints of skin, and hair, and eyes, would cease to be disadvantageous whenever they were accompanied by superior brain-power. Such variations would then be preserved; and thus may have arisen the Xanthochroic race of mankind, in which we find a high development of intellect accompanied by a slight deficiency in the acuteness of the senses as compared with the darker forms.

I have now to ask your attention to a few remarks on the peculiar relations of plants and insects as exhibited in islands.

Ever since Mr. Darwin showed the immense importance of insects in the fertilization of flowers, great attention has been paid to the subject, and the relation of these two very different classes of natural objects has been found to be more universal

and more complex than could have been anticipated. Whole genera and families of plants have been so modified, as first to attract, and then to be fertilized by, certain groups of insects, and this special adaptation seems in many cases to have determined the more or less wide range of the plants in question. It is also known that some species of plants can be fertilized only by particular species of insects, and the absence of these from any locality would necessarily prevent the continued existence of the plant in that area. Here, I believe, will be found the clue to much of the peculiarity of the floras of oceanic islands, since the methods by which they have been stocked with plants and insects will be often quite different. Many seeds are, no doubt, carried by oceanic currents, others probably by aquatic birds. Mr. H. N. Moseley informs me that the albatrosses, gulls, puffins, tropic birds, and many others, nest inland, often amidst dense vegetation, and he believes they often carry seeds, attached to their feathers, from island to island for great distances. In the tropics they often nest on the mountains far inland, and may thus aid in the distribution even of mountain plants. Insects, on the other hand, are mostly conveyed by aërial currents, especially by violent gales; and it may thus often happen that totally unrelated plants and insects may be brought together, in which case the former must often perish for want of suitable insects to fertilize them. This will, I think, account for the strangely fragmentary nature of these insular floras, and the great distances that often exist between those which are situated in the same ocean, as well as for the preponderance of certain orders and genera. In Mr. Pickering's valuable work on the Geographical Distribution of Animals and Plants, he gives a list of no less than sixty-six natural orders of plants *unexpectedly* absent from Tahiti, or which occur in many of the surrounding lands, some being abundant in other islands—as the Labiatæ at the Sandwich Islands. In these latter islands the flora is much richer, yet a large number of families which abound in other parts of Polynesia are totally wanting. Now much of the poverty and exceptional distribution of the plants of these islands is probably due to the great scarcity of flower-frequenting insects. Lepidoptera and Hymenoptera are exceedingly scarce in the eastern islands of the Pacific, and it is almost certain that many plants which require these insects for their fertilization have been thereby prevented from establishing themselves. In the Western islands, such as the Fijis, several species of butterflies occur in tolerable abundance, and no doubt some flower-haunting Hymenoptera accompany them, and in these islands the flora appears to be much more varied, and especially to be characterized by a much greater variety of showy flowers,

as may be seen by examining the plates of Dr. Seeman's "Flora Vitiensis."

Darwin and Pickering both speak of the great preponderance of ferns at Tahiti, and Mr. Moseley, who spent several days in the interior of the island, informs me that "at an elevation of from 2,000 to 3,000 feet the dense vegetation is composed almost entirely of ferns. A tree fern (*Alsophila Tahitensis*) forms a sort of forest, to the exclusion of almost every other tree, and, with huge plants of two other ferns (*Angiopteris evecta* and *Aspelenium nidus*), forms the main mass of the vegetation." And he adds, "I have nowhere seen ferns in so great proportionate abundance." This unusual proportion of ferns is a general feature of insular as compared with continental floras; but it has, I believe, been generally attributed to favorable conditions, especially to equable climate and perennial moisture. In this respect, however, Tahiti can hardly differ greatly from many other islands, which yet have no such vast preponderance of ferns. This is a question that cannot be decided by mere lists of species, since it is probable that in Tahiti they are less numerous than in some other islands where they form a far less conspicuous feature in the vegetation. The island most comparable with Tahiti in that respect is Juan Fernandez. Mr. Moseley writes to me—"In a general view of any wide stretch of densely-clothed mountainous surface of the island, the ferns, both tree-ferns and the unstemmed forms, are seen at once to compose a very large proportion of the mass of foliage." As to the insects of Juan Fernandez, Mr. Edwyn C. Reed, who made two visits and spent several weeks there, has kindly furnished me with some exact information. Of butterflies there is only one (*Pyrameis carie*), and that rare—a Chilian species, and probably an accidental straggler. Four species of moths of moderate size were observed—all Chilian, and a few larvæ and pupæ. Of bees there were none, except one very minute species (allied to *Chilicola*), and of other Hymenoptera, a single specimen of *Ophion luteus*—a cosmopolitan ichneumon. About twenty species of flies were observed, and these formed the most prominent feature of the entomology of the island.

Now, as far as we know, the extreme entomological poverty agrees closely with that of Tahiti; and there are probably no other portions of the globe equally favored in soil and climate and with an equally luxuriant vegetation, where insect-life is so scantily developed. It is curious therefore to find that these two islands also agree in the wonderful predominance of ferns over the flowering plants—in individuals even more than in species, and there is no difficulty in connecting the two facts. The excessive minuteness and great abundance of fern-spores causes them to be far more easily distributed by winds than the

seeds of flowering plants, and they are thus always ready to occupy any vacant places in suitable localities, and to compete with the less vigorous flowering plants. But where insects are so scarce, all plants which require insect fertilization, whether constantly to enable them to produce seed at all, or occasionally to keep up their constitutional vigor by crossing, must be at a great disadvantage; and thus the scanty flora which oceanic islands must always possess, peopled as they usually are by waifs and strays from other lands, is rendered still more scanty by the weeding out of all such as depend largely on insect fertilization for their full development. It seems probable, therefore, that the preponderance of ferns in islands (considered in mass of individuals rather than in number of species) is largely due to the absence of competing phenogamous plants; and that this is in great part due to the scarcity of insects. In other oceanic islands, such as New Zealand and the Galapagos, where ferns, although tolerably abundant, form no such predominant feature in the vegetation, but where the scarcity of flower-haunting insects is almost equally marked, we find a great preponderance of small green, or otherwise inconspicuous flowers, indicating that only such plants have been enabled to flourish there as are independent of insect fertilization. In the Galapagos—which are perhaps even more deficient in flying insects than Juan Fernandez—this is so striking a feature that Mr. Darwin speaks of the vegetation as consisting in great part of "wretched-looking weeds," and states that "it was some time before he discovered that almost every plant was in flower at the time of his visit." He also says that he "did not see one beautiful flower" in the islands. It appears, however, that Compositæ, Leguminosæ, Rubiaceæ, and Solanaceæ, form a large proportion of the flowering plants, and as these are orders which usually require insect fertilization, we must suppose either that they have become modified so as to be self-fertilized, or that they are fertilized by the visits of the minute Diptera and Hymenoptera, which are the only insects recorded from these islands.

In Juan Fernandez, on the other hand, there is no such total deficiency of showy flowers. I am informed by Mr. Moseley that a variety of the Magnoliaceous winter's bark abounds, and has showy white flowers, and that a Bignoniaceous shrub with abundance of dark blue flowers, was also plentiful; while a white-flowered Liliaceous plant formed large patches on the hill-sides. Besides these there were two species of woody Compositæ with conspicuous heads of yellow blossoms, and a species of white-flowered myrtle also abundant; so that, on the whole, flowers formed a rather conspicuous feature in the aspect of the vegetation of Juan Fernandez.

But this fact—which at first sight seems entirely at variance

with the view we are upholding of the important relation between the distribution of insects and plants—is well explained by the existence of two species of humming birds in Juan Fernandez, which, in their visits to these large and showy flowers fertilize them as effectually as bees, moths, or butterflies. Mr. Moseley informs me that "these humming birds are *extraordinarily abundant*, every tree or bush having one or two darting about it." He also observed that "nearly all the specimens killed had the feathers round the base of the bill and front of the head clogged and colored yellow with pollen." Here, then, we have the clue to the perpetuation of large and showy flowers in Juan Fernandez; while the total absence of humming-birds in the Galapagos may explain why no such large-flowered plants have been able to establish themselves in those equatorial islands.

This leads to the observation that many other groups of birds also, no doubt, aid in the fertilization of flowers. I have often observed the beaks and faces of the brush-tongued lories of the Moluccas covered with pollen; and Mr. Moseley noted the same fact in a species of *Artamus*, or swallow-shrike, shot at Cape York, showing that this genus also frequents flowers and aids in their fertilization. In the Australian region we have the immense group of the Meliphagidæ, which all frequent flowers, and as these range over all the islands of the Pacific, their presence will account for a certain proportion of showy flowers being found there, such as the scarlet *Metrosideros*, one of the few conspicuous flowers in Tahiti. In the Sandwich Islands, too, there are forests of *Metrosideros*; and Mr. Charles Pickering writes me, that they are visited by honey-sucking birds, one of which is captured by sweetened bird-lime, against which it thrusts its extensile tongue. I am also informed that a considerable number of flowers are occasionally fertilized by humming-birds in North America; so that there can, I think, be little doubt that birds play a much more important part in this respect than has hitherto been imagined. It is not improbable that in Tropical America, where this family is so enormously developed, many flowers will be found to be expressly adapted to fertilization by them just as so many in our own country are specially adapted to the visits of certain families or genera of insects.

It must also be remembered, as Mr. Moseley has suggested to me, that a flower which had acquired a brilliant color to attract insects might, on transference to another country, and becoming so modified as to be capable of self-fertilization, retain the colored petals for an indefinite period. Such is probably the explanation of the *Pelargonium* of Kerguelen's land, which forms masses of bright color near the shore during the flower-

ing season; while most of the other plants of the island have colorless flowers in accordance with the almost total absence of winged insects. The presence of many large and showy flowers among the indigenous flora of St. Helena must be an example of a similar persistence. Mr. Melliss indeed states it to be "a remarkable peculiarity that the indigenous flowers are, with very slight exceptions, all perfectly colorless;"* but although this may apply to the general aspect of the remains of the indigenous flora, it is evidently not the case as regards the *species*, since the interesting plates of Mr. Melliss's volume show that about one-third of the indigenous flowering plants have more or less colored or conspicuous flowers, while several of them are exceedingly showy and beautiful. Among these are a *Lobelia*, three *Wahlenbergias*, several *Compositæ*, and especially the handsome red flowers of the now almost extinct forest-trees, the ebony and redwood (species of *Melhania*, Byttneriaceæ). We have every reason to believe, however, that when St. Helena was covered with luxuriant forests, and especially at that remote period when it was much more extensive than it is now, it must have supported a certain number of indigenous birds and insects, which would have aided in the fertilization of these gaily-colored flowers. The researches of Dr. Hermann Müller have shown us by what minute modification of structure or of function many flowers are adapted for partial insect and self-fertilization in varying degrees, so that we have no difficulty in understanding how, as the insects diminished and finally disappeared, self-fertilization may have become the rule, while the large and showy corollas remain to tell us plainly of a once different state of things.

Another interesting fact in connection with this subject is the presence of arborescent forms of Compositæ in so many of the remotest oceanic islands. They occur in the Galapagos, in Juan Fernandez, in St. Helena, in the Sandwich Islands, and in New Zealand; but they are not directly related to each other, representatives of totally different tribes of this extensive order becoming arborescent in each group of islands. The immense range and almost universal distribution of the Compositæ is due to the combination of a great facility of distribution (by their seeds), with a great attractiveness to insects, and the capacity of being fertilized by a variety of species of all orders, and especially by flies and small beetles. Thus they would be among the earliest of flowering plants to establish themselves on oceanic islands; but where insects of all kinds were very scarce it would be an advantage to gain increased size and longevity, so that fertilization at an interval of several years might suffice for the continuance of the species. The arborescent form would com-

* Melliss's *St. Helena*, p. 226, note.

bine with increased longevity the advantage of increased size in the struggle for existence with the ferns and other early colonists, and these advantages have led to its being independently produced in so many distant localities, whose chief feature in common is their remoteness from continents and the extreme poverty of their insect life.

As the sweet odors of flowers are known to act in combination with their colors, as an attraction to insects, it might be anticipated that where color was deficient scent would be so also. On applying to my friend Dr. Hooker for information as to New Zealand plants, he informed me that this was certainly the case, and that the New Zealand flora is, speaking generally, as strikingly deficient in sweet odors as in conspicuous colors. Whether this peculiarity occurs in other islands I have not been able to obtain information, but we may certainly expect it to be so in such a marked instance as that of the Galapagos flora.

Another question which here comes before us is the origin and meaning of the odoriferous glands of leaves. Dr. Hooker informed me that not only are New Zealand plants deficient in scented flowers, but equally so in scented leaves. This led me to think that perhaps such leaves were in some way an additional attraction to insects, though it is not easy to understand how this could be, except by adding a general attraction to the special attraction of the flowers, or by supporting the larvæ, which as perfect insects aid in fertilization. Mr. Darwin, however, informs me that he considers that leaf-glands bearing essential oils are a protection against the attacks of insects where these abound, and would thus not be required in countries where insects were very scarce. But it seems opposed to this view that highly aromatic plants are characteristic of deserts all over the world, and in such places insects are not abundant. Mr. Stainton informs me that the aromatic Labiatæ enjoy no immunity from insect attacks. The bitter leaves of the cherry-laurel are often eaten by the larvæ of moths that abound on our fruit-trees; while in the Tropics the leaves of the orange tribe are favorites with a large number of lepidopterous larvæ; and our northern firs and pines, although abounding in a highly aromated resin, are very subject to the attacks of beetles. My friend Dr. Richard Spruce—who while traveling in South America allowed nothing connected with plant-life to escape his observation—informs me that trees whose leaves have aromatic and often resinous secretions in immersed glands abound in the plains of tropical America, and that such are in great part, if not wholly, free from the attacks of leaf-eating ants, except where the secretion is only slightly bitter, as in the orange tribe, orange-trees being sometimes entirely denuded

of their leaves in a single night. Aromatic plants abound in the Andes up to about 13,000 feet, as well as in the plains, but hardly more so than in Central and Southern Europe. They are perhaps most plentiful in the dry mountainous parts of Southern Europe; and as neither here nor in the Andes do leaf-eating ants exist, Dr. Spruce infers that, although in the hot American forests where such ants swarm the oil-bearing glands serve as a protection, yet they were not originally acquired for that purpose. Near the limits of perpetual snow on the Andes such plants as occur are not, so far as Dr. Spruce has observed, aromatic; and as plants in such situations can hardly depend on insect visits for their fertilization, the fact is comparable with that of the flora of New Zealand, and would seem to imply some relation between the two phenomena, though what it exactly is cannot yet be determined.

I trust I have now been able to show you that there are a number of curious problems lying as it were on the outskirts of biological inquiry which well merit attention, and which may lead to valuable results. But these problems are, as you see, for the most part connected with questions of locality, and require full and accurate knowledge of the productions of a number of small islands and other limited areas, and the means of comparing them the one with the other. To make such comparisons is, however, now quite impossible. No museum contains any fair representation of the productions of these localities, and such specimens as do exist, being scattered through the general collection, are almost useless for this special purpose. If, then, we are to make any progress in this inquiry, it is absolutely essential that some collectors should begin to arrange their cabinets primarily on a geographical basis, keeping together the productions of every island or group of islands, and of such divisions of each continent as are found to possess any special or characteristic fauna or flora. We shall then be sure to detect many unsuspected relations between the animals and plants of certain localities, and we shall become much better acquainted with those complex reactions between the vegetable and animal kingdoms, and between the organic world and the inorganic, which have almost certainly played an important part in determining many of the most conspicuous features of living things.

3. *Rise and Progress of Modern Views as to the Antiquity and Origin of Man.*

I now come to a branch of our subject which I would gladly have avoided touching on, but as the higher powers of this Association have decreed that I should preside over the Anthropological Department, it seems proper that I should devote

some portion of my address to matters more immediately connected with the special study to which that department is devoted.

As my own knowledge of, and interest in, Anthropology, is confined to the great outlines, rather than to the special details of the science, I propose to give a very brief and general sketch of the modern doctrine as to the Antiquity and Origin of Man, and to suggest certain points of difficulty which have not, I think, yet received sufficient attention.

Many now present remember the time (for it is a little more than twenty years ago) when the antiquity of man, as now understood, was universally discredited. Not only theologians, but even geologists, then taught us that man belonged altogether to the existing state of things; that the extinct animals of the Tertiary period had finally disappeared, and that the earth's surface had assumed its present condition before the human race first came into existence. So prepossessed were even scientific men with this idea—which yet rested on purely negative evidence, and could not be supported by any arguments of scientific value—that numerous facts which had been presented at intervals for half a century, all tending to prove the existence of man at very remote epochs, were silently ignored; and, more than this, the detailed statements of three distinct and careful observers were rejected by a great scientific society as too improbable for publication, only because they proved (if they were true) the co-existence of man with extinct animals!*

But this state of belief in opposition to facts could not long continue. In 1859 a few of our most eminent geologists examined for themselves into the alleged occurrence of flint implements in the gravels of the North of France, which had been made public fourteen years before, and found them strictly correct. The caverns of Devonshire were about the same time carefully examined by equally eminent observers, and were found fully to bear out the statement of those who had published their results eighteen years before. Flint implements began to be found in all suitable localities in the South of England, when carefully searched for, often in gravels of equal antiquity with those of France. Caverns, giving evidence of human occupation at various remote periods, were explored in Belgium and the South of France,—lake dwellings were examined in Switzerland—refuse heaps in Denmark—and thus a whole series of remains have been discovered carrying back the history of mankind from the earliest historic periods to a

* In 1854 (?) a communication from the Torquay Natural History Society confirming previous accounts by Mr. Godwin-Austen, Mr. Vivian, and the Rev. Mr. McEnery, that worked flints occurred in Kent's Hole with remains of extinct species, was rejected as too improbable for publication.

long distant past. The antiquity of the races thus discovered can only be generally determined by the successively earlier and earlier stages through which we can trace them. As we go back, metals soon disappear and we find only tools and weapons of stone and of bone. The stone weapons get ruder and ruder; pottery, and then the bone implements, cease to occur; and in the earliest stage we find only chipped flints, of rude design though still of unmistakable human workmanship. In like manner domestic animals disappear as we go backward; and though the dog seems to have been the earliest, it is doubtful whether the makers of the ruder flint implements of the gravels possessed even this. Still more important as a measure of time are the changes of the earth's surface—of the distribution of animals—and of climate—which have occurred during the human period. At a comparatively recent epoch in the record of prehistoric times we find that the Baltic was far salter than it is now, and produced abundance of oysters; and that Denmark was covered with pine forests inhabited by Capercailzies, such as now only occur further north in Norway. A little earlier we find that Reindeer were common even in the South of France, and still earlier this animal was accompanied by the mammoth and woolly rhinoceros, by the arctic glutton, and by huge bears and lions of extinct species. The presence of such animals implies a change of climate, and both in the caves and gravels we find proofs of a much colder climate than now prevails in Western Europe. Still more remarkable are the changes of the earth's surface which have been effected during man's occupation of it. Many extensive valleys in England and France are believed by the best observers to have been deepened at least a hundred feet; caverns now far out of the reach of any stream must for a long succession of years have had streams flowing through them, at least in times of floods—and this often implies that vast masses of solid rock have since been worn away. In Sardinia land has risen at least 300 feet since men lived there who made pottery and probably used fishing-nets;* while in Kent's Cavern remains of man are found buried beneath two separate beds of stalagmite, each having a distinct texture, and each covering a deposit of cave-earth having well-marked differential characters, while each contains a distinct assemblage of extinct animals.

Such, briefly, are the results of the evidence that has been rapidly accumulating for about fifteen years as to the antiquity of man; and it has been confirmed by so many discoveries of a like nature in all parts of the globe, and especially by the comparison of the tools and weapons of prehistoric man with those of modern savages, so that the use of even the rudest flint im-

* Lyell's Antiquity of Man, fourth edition, p. 115.

plements has become quite intelligible,—that we can hardly wonder at the vast revolution effected in public opinion. Not only is the belief in man's vast and still unknown antiquity universal among men of science, but it is hardly disputed by any well-informed theologian; and the present generation of science-students must, we should think, be somewhat puzzled to understand, what there was in the earlier discoveries that should have aroused such general opposition and been met with such universal incredulity.

But the question of the mere "Antiquity of Man" almost sank into insignificance at a very early period of the inquiry, in comparison with the far more momentuous and more exciting problem of the development of man from some lower animal form, which the theories of Mr. Darwin and of Mr. Herbert Spencer soon showed to be inseparably bound up with it. This has been, and to some extent still is, the subject of fierce conflict; but the controversy as to the fact of such development is now almost at an end, since one of the most talented representatives of Catholic theology, and an anatomist of high standing —Professor Mivart—fully adopts it as regards physical structure, reserving his opposition for those parts of his theory, which would deduce man's whole intellectual and moral nature from the same source, and by a similar mode of development.

Never, perhaps, in the whole history of science or philosophy has so great a revolution in thought and opinion been effected as in the twelve years from 1859 to 1871, the respective dates of publication of Mr. Darwin's "Origin of Species" and "Descent of Man." Up to the commencement of this period the belief in the independent creation or origin of the species of animals and plants, and the very recent appearance of man upon the earth, were, practically, universal. Long before the end of it these two beliefs had utterly disappeared, not only in the scientific world, but almost equally so among the literary and educated classes generally. The belief in the independent origin of man held its ground somewhat longer, but the publication of Mr. Darwin's great work gave even that its deathblow, for hardly anyone capable of judging of the evidence now doubts the derivative nature of man's bodily structure as a whole, although many believe that his mind and even some of his physical characteristics may be due to the action of other forces than have acted in the case of the lower animals.

We need hardly be surprised, under these circumstances, if there has been a tendency among men of science to pass from one extreme to the other, from a profession (so few years ago) of total ignorance as to the mode of origin of all living things, to a claim to almost complete knowledge, of the whole progress of the universe, from the first speck of living protoplasm up to

the highest development of the human intellect. Yet this is really what we have seen in the last sixteen years. Formerly difficulties were exaggerated, and it was asserted that we had not sufficient knowledge to venture on any generalizations on the subject. Now difficulties are set aside, and it is held that our theories are so well established and so far-reaching, that they explain and comprehend all nature. It is not long ago (as I have already reminded you) since *facts* were contemptuously ignored, because they favored our now popular views; at the present day it seems to me that facts which oppose them hardly receive due consideration. And as opposition to the best incentive to progress, and it is not well even for the best theories to have it all their own way, I propose to direct your attention to a few such facts, and to the conclusion that seems fairly deducible from them.

It is a curious circumstance, that notwithstanding the attention that has been directed to the subject in every part of the world, and the numerous excavations connected with railways and mines which have offered such facilities for geological discovery, no advance whatever has been made for a considerable number of years, in detecting the time or the mode of man's origin. The Palæolithic flint weapons first discovered in the North of France more than thirty years ago, are still the oldest undisputed proofs of man's existence; and amid the countless relics of a former world that have been brought to light, no evidence of any one of the links that must have connected man with the lower animals has yet appeared.

It is, indeed, well known that negative evidence in geology is of very slender value, and this is, no doubt, generally the case. The circumstances here are, however, peculiar, for many converging lines of evidence show that on the theory of development by the same laws which have determined the development of the lower animals, man must be immensely older than any traces of him yet discovered. As this is a point of great interest we must devote a few moments to its consideration.

1. The most important difference between man and such of the lower animals as most nearly approach him, is undoubtedly in the bulk and development of his brain, as indicated by the form and capacity of the cranium. We should therefore anticipate that these earliest races, who were contemporary with the extinct animals and used rude stone weapons, would show a marked deficiency in this respect. Yet the oldest known crania—those of the Engis and Cro-Magnon caves—show no marks of degradation. The former does not present so low a type as that of most existing savages, but is—to use the words of Prof. Huxley—"a fair average human skull, which might have belonged to a philosopher, or might have contained the

thoughtless brains of a savage." The latter are still more remarkable, being unusually large and well-formed. Dr. Pruner-Bey states that they surpass the average of modern European skulls in capacity, while their symmetrical forms, without any trace of prognathism, compares favorably not only with the foremost savage races, but with many civilized nations of modern times.

One or two other crania of much lower type, but of less antiquity than this, have been discovered; but they in no way invalidate the conclusion which so highly developed a form at so early a period implies, viz., that we have as yet made a hardly perceptible step toward the discovery of any earlier stage in the development of man.

2. This conclusion is supported and enforced by the nature of many of the works of art found even in the oldest cave-dwellings. The flints are of the old chipped type, but they are formed into a large variety of tools and weapons—such as scrapers, awls, hammers, saws, lances, &c., implying a variety of purposes for which these were used, and a corresponding degree of mental activity and civilization. Numerous articles of bone have also been found, including well-formed needles, implying that skins were sewn together, and perhaps even textile materials woven into cloth. Still more important are numerous carvings and drawings representing a variety of animals, including horses, reindeer, and even a mammoth, executed with considerable skill on bone, reindeer-horns, and mammoth-tusks. These, taken together, indicate a state of civilization much higher than that of the lowest of our modern savages, while it is quite compatible with a considerable degree of mental advancement, and leads us to believe that the crania of Engis and Cro-Magnon are not exceptional, but fairly represent the characters of the race. If we further remember that these people lived in Europe under the unfavorable conditions of a sub-Arctic climate, we shall be inclined to agree with Dr. Daniel Wilson, that it is far easier to produce evidences of deterioration than of progress in instituting a comparison between the contemporaries of the mammoth and later prehistoric races of Europe or savage nations of modern times.*

3. Yet another important line of evidence as to the extreme antiquity of the human type has been brought prominently forward by Prof. Mivart.† He shows by a careful comparison of all parts of the structure of the body, that man is related, not to any one, but almost equally to many of the existing apes—to the orang, the chimpanzee, the gorilla, and even to the gibbons—in a variety of ways; and these relations and differ-

* "Prehistoric Man," 3d ed., vol. i, p. 117.

† "Man and Apes," pp. 171–193.

ences are so numerous and so diverse that on the theory of evolution the ancestral form which ultimately developed into man must have diverged from the common stock whence all these various forms and their extinct allies originated. But so far back as the Miocene deposits of Europe, we find the remains of apes allied to these various forms, and especially to the gibbons, so that in all probability the special line of variation which led up to man branched off at a still earlier period. And these early forms, being the initiation of a far higher type, and having to develop by natural selection into so specialized and altogether distinct a creature as man, must have risen at a very early period into the position of a dominant race, and spread in dense waves of population over all suitable portions of the great continent—for this, on Mr. Darwin's hypothesis, is essential to rapid developmental progress through the agency of natural selection.

Under these circumstances we might certainly expect to find some relics of these earlier forms of man along with those of animals which were presumably less abundant. Negative evidence of this kind is not very weighty, but still it has *some* value. It has been suggested that as apes are mostly tropical, and the anthropoid apes are now confined almost exclusively to the vicinity of the equator, we should expect the ancestral forms also to have inhabited these same localities—West Africa and the Malay islands. But this objection is hardly valid, because existing anthropoid apes are wholly dependent on a perennial supply of easily accessible fruits, which is only found near the equator, while not only had the south of Europe an almost tropical climate in Miocene times, but we must suppose even the earliest ancestors of man to have been terrestrial and omnivorous, since it must have taken ages of slow modification to have produced the perfectly erect form, the short arms, and the wholly non-prehensile foot, which so strongly differentiate man from the apes.

The conclusion which I think we must arrive at is, that if man has been developed from a common ancestor, with all existing apes, *and by no other agencies than such as have affected their development*, then he must have existed in something approaching his present form, during the tertiary period—and not merely existed, but predominated in numbers, wherever suitable conditions prevail. If then continued researches in all parts of Europe and Asia fail to bring to light any proofs of his presence, it will be at least a presumption that he came into existence at a much later date, and by a much more rapid process of development. In that case it will be a fair argument, that, just as he is in his mental and moral nature, his capacities and aspirations, so infinitely raised above the brutes, so his

origin is due to distinct and higher agencies than such as have affected their development.

There is yet another line of inquiry bearing upon this subject to which I wish to call your attention. It is a somewhat curious fact, that, while all modern writers admit the great antiquity of man, most of them maintain the very recent development of his intellect, and will hardly contemplate the possibility of men equal in mental capacity to ourselves, having existed in prehistoric times. This question is generally assumed to be settled, by such relics as have been preserved of the manufactures of the older races showing a lower and lower state of the arts; by the successive disappearance in early times of iron, bronze, and pottery; and by the ruder forms of the older flint implements. The weakness of this argument has been well shown by Mr. Albert Mott in his very original, but little known presidential address to the Literary and Philosophical Society of Liverpool in 1873. He maintains that "our most distant glimpses of the past are still of a world peopled as now with men both civilized and savage"—and, "that we have often entirely misread the past by supposing that the outward signs of civilization must always be the same, and must be such as are found among ourselves." In support of this view he adduces a variety of striking facts and ingenious arguments, a few of which I will briefly summarize.

On one of the most remote islands of the Pacific—Easter Island—2,000 miles from South America, 2,000 from the Marquesas, and more than 1,000 from the Gambier Islands, are found hundreds of gigantic stone images, now mostly in ruins, often thirty or forty feet high, while some seem to have been much larger, the crowns on their heads cut out of a red stone being sometimes ten feet in diameter, while even the head and neck of one is said to have been twenty feet high.* These once stood erect on extensive stone platforms, yet the island has only an area of about thirty square miles, or considerably less than Jersey. Now as one of the smallest images eight feet high weighs four tons, the largest must weigh over a hundred tons, if not much more; and the existence of such vast works implies a large population, abundance of food, and an established government. Yet how could these coexist in a mere speck of land wholly cut off from the rest of the world? Mr. Mott maintains that this necessarily implies the power of regular communication with larger islands or a continent, the arts of navigation, and a civilization much higher than now exists in any part of the Pacific. Very similar remains in other islands scattered widely over the Pacific add weight to this argument.

* Journ. of Roy. Geog. Soc., 1870, pp. 177, 178.

The next example is that of the ancient mounds and earthworks of the North American continent, the bearing of which is even more significant. Over the greater part of the extensive Mississippi valley four well-marked classes of these earthworks occur. Some are camps, or works of defence, situated on bluffs, promontories, or isolated hills; others are vast inclosures in the plains and lowlands, often of geometric forms, and having attached to them roadways or avenues often miles in length; a third are mounds corresponding to our tumuli, often seventy to ninety feet high, and some of them covering acres of ground; while a fourth group consist of representations of various animals modelled in relief on a gigantic scale, and occurring chiefly in an area somewhat to the north-west of the other classes, in the plains of Wisconsin.

The first class—the camps or fortified inclosures—resemble in general features the ancient camps of our own islands, but far surpass them in extent. Fort Hill, in Ohio, is surrounded by a wall and a ditch a mile and a half in length, part of the way cut through solid rock. Artificial reservoirs for water were made within it, while at one extremity, on a more elevated point, a keep is constructed with its separate defences and water-reservoirs. Another, called Clark's Work, in the Scioto valley, which seems to have been a fortified town, incloses an area of 127 acres, the embankments measuring three miles in length, and containing not less than three million cubic feet of earth. This area incloses numerous sacrificial mounds and symmetrical earth-works in which many interesting relics and works of art have been found.

The second class—the sacred inclosures—may be compared for extent and arrangement with Avebury or Carnak—but are in some respects even more remarkable. One of these, at Newark, Ohio, covers an area of several miles with its connected groups or circles, octagons, squares, ellipses, and avenues, on a grand scale, and formed by embankments from twenty to thirty feet in height. Other similar works occur in different parts of Ohio, and by accurate survey it is found not only that the circles are true, though some of them are one-third of a mile in diameter, but that other figures are truly square, each side being over 1,000 feet long, and, what is still more important, the dimensions of some of these geometrical figures in different parts of the country and seventy miles apart are identical. Now this proves the use, by the builders of these works, of some standard measures of length, while the accuracy of the squares, circles, and, in a less degree, of the octagonal figures—shows a considerable knowledge of rudimentary geometry, and some means of measuring angles. The difficulty of drawing such figures on a large scale is much

greater than any one would imagine who has not tried it, and the accuracy of these is far beyond what is necessary to satisfy the eye. We must therefore impute to these people the wish to make these figures as accurate as possible, and this wish is a greater proof of habitual skill and intellectual advancement than even the ability to draw such figures. If, then, we take into account this ability and this love of geometric truth, and further consider the dense population and civil organization implied by the construction of such extensive systematic works we must allow that these people had reached the earlier stages of a civilization of which no traces existed among the savage tribes who alone occupied the country when first visited by Europeans.

The animal mounds are of comparatively less importance for our present purpose, as they imply a somewhat lower grade of advancement; but the sepulchral and sacrificial mounds exist in vast numbers, and their partial exploration has yielded a quantity of articles and works of art, which throw some further light on the peculiarities of this mysterious people. Most of these mounds contain a large concave hearth or basis of burnt clay, of perfectly symmetrical form, on which are found deposited more or less abundant relics, all bearing traces of the action of fire. We are, therefore, only acquainted with such articles as are practically fire-proof. These consist of bone and copper implements and ornaments, discs, and tubes—pearl, shell and silver beads, more or less injured by the fire—ornaments cut in mica, ornamental pottery, and numbers of elaborate carvings in stone, mostly forming pipes for smoking. The metallic articles are all formed by hammering, but the execution is very good; plates of mica are found cut into scrolls and circles; the pottery, of which very few remains have been found, is far superior to that of any of the Indian tribes, since Dr. Wilson is of opinion that they must have been formed on a wheel, as they are often of uniform thickness throughout (sometimes not more than one-sixth of an inch) polished, and ornamented with scrolls and figures of birds and flowers in delicate relief. But the most instructive objects are the sculptured stone pipes, representing not only various easily recognizable animals, but also human heads, so well executed that they appear to be portraits. Among the animals, not only are such native forms as the panther, bear, otter, wolf, beaver, raccoon, heron, crow, turtle, frog, rattlesnake, and many others, well represented, but also the manatee, which perhaps then ascended the Mississippi as it now does the Amazon, and the toucan, which could hardly have been obtained nearer than Mexico. The sculptured heads are especially remarkable, because they present to us the features of an intellectual and civilized people. The nose in some is perfectly straight, and

neither prominent nor dilated, the mouth is small, and the lips thin, the chin and upper lip are short, contrasting with the ponderous jaw of the modern Indian, while the cheek-bones present no marked prominence. Other examples have the nose somewhat projecting at the apex in a manner quite unlike the features of any American indigenes, and, although there are some which show a much coarser face, it is very difficult to see in any of them that close resemblance to the Indian type which these sculptures have been said to exhibit. The few authentic crania from the mounds present corresponding features, being far more symmetrical and better developed in the frontal region than those of any American tribes, although somewhat resembling them in the occipital outline;* while one was described by its discoverer (Mr. W. Marshall Anderson) as "a beautiful skull worthy of a Greek."

The antiquity of this remarkable race may perhaps not be very great, as compared with the prehistoric man of Europe, although the opinions of some writers on the subject seem affected by that "parsimony of time" on which the late Sir Charles Lyell so often dilated. The mounds are all overgrown with dense forest, and one of the large trees was estimated to be eight hundred years old, while other observers consider the forest growth to indicate an age of at least 1,000 years. But it is well known that it requires several generations of trees to pass away before the growth on a deserted clearing comes to correspond with that of the surrounding virgin forest, while this forest, once established, may go on growing for an unknown number of thousands of years. The 800 or 1,000 years' estimate from the growth of existing vegetation is a minimum which has no bearing whatever on the actual age of these mounds, and we might almost as well attempt to determine the time of the glacial epoch from the age of the pines or oaks which now grow on the moraines.

The important thing for us, however, is that when North America was first settled by Europeans, the Indian tribes inhabiting it had no knowledge or tradition of any preceding race of higher civilization than themselves. Yet we find that such a race existed; that they must have been populous and have lived under some established government; while there are signs that they practised agriculture largely, as indeed they must have done to have supported a population capable of executing such gigantic works in such vast profusion—for it is stated that the mounds and earthworks of various kinds in the State of Ohio alone amount to between eleven and twelve thousand. In their habits, customs, religion, and arts, they differed strikingly from all the Indian tribes; while their love

* Wilson's "Prehistoric Man," 3d ed., vol. ii, pp. 123–130.

of art and of geometric forms, and their capacity for executing the latter upon so gigantic a scale, render it probable that they were a really civilized people, although the form their civilization took may have been very different from that of later people subject to very different influences, and the inheritors of a longer series of ancestral civilizations. We have here, at all events, a striking example of the transition, over an extensive country, from comparative civilization to comparative barbarism, the former having left no tradition, and hardly any trace of influence on the latter.

As Mr. Mott well remarks:—Nothing can be more striking than the fact that Easter Island and North America both give the same testimony as to the origin of the savage life found in them, although in all circumstances and surroundings the two cases are so different. If no stone monuments had been constructed in Easter Island, or mounds, containing a few relics saved from fire, in the United States, we might never have suspected the existence of these ancient peoples. He argues, therefore, that it is very easy for the records of an ancient nation's life entirely to perish, or to be hidden from observation. Even the arts of Nineveh and Babylon were unknown only a generation ago, and we have only just discovered the facts about the mound-builders of North America.

But other parts of the American continent exhibit parallel phenomena. Recent investigations show that in Mexico, Central America, and Peru, the existing race of Indians has been preceded by a distinct and more civilized race. This is proved by the sculptures of the ruined cities of Central America, by the more ancient terra-cottas and paintings of Mexico, and by the oldest protrait-pottery of Peru. All alike show markedly non-Indian features, while they often closely resemble modern European types. Ancient crania, too, have been found in all these countries, presenting very different characters from those of any of the modern indigenous races of America.*

There is one other striking example of a higher being succeeded by a lower degree of knowledge, which is in danger of being forgotten because it has been made the foundation of theories which seem wild and fantastic, and are probably in great part erroneous. I allude to the Great Pyramid of Egypt, whose form, dimensions, structure, and uses have recently been the subject of elaborate works by Professor Piazzi Smyth. Now, the admitted fact about this pyramid are so interesting and so apposite to the subject we are considering, that I beg to recall them to your attention. Most of you are aware that this pyramid has been carefully explored and measured by successive Egyptologists, and that the dimensions have lately become

* Wilson's "Prehistoric Man," 3d ed., vol. ii, pp. 125, 144.

capable of more accurate determination owing to the discovery of some of the original casing-stones and the clearing away of the earth from the corners of the foundation, showing the sockets in which the corner-stones fitted. Professor Smyth devoted many months of work with the best instruments in order to fix the dimensions and angles of all accessible parts of the structure; and he has carefully determined these by a comparison of his own and all previous measures, the best of which agree pretty closely with each other. The results arrived at are—

1. That the pyramid is truly square, the sides being equal and the angles right angles.
2. That the four sockets on which the four first stones of the corners rested are truly on the same level.
3. That the direction of the sides are accurately to the four cardinal points.
4. That the vertical height of the pyramid bears the same proportion to its circumference at the base, as the radius of a circle does to its circumference.

Now all these measures, angles, and levels are accurate, not as an ordinary surveyor or builder could make them, but to such a degree as requires the very best modern instruments and all the refinements of geodetical science to discover any error at all. In addition to this we have the wonderful perfection of the workmanship in the interior of the pyramid, the passages and chambers being lined with huge blocks of stones fitted with the utmost accuracy, while every part of the building exhibits the highest structural science.

In all these respects this largest pyramid surpasses every other in Egypt. Yet it is universally admitted to be the oldest, and also the oldest historical building in the world.

Now these admitted facts about the Great Pyramid are surely remarkable, and worthy of the deepest consideration. They are facts which, in the pregnant words of the late Sir John Herschel, "according to received theories ought not to happen," and which, he tells us, should therefore be kept ever present to our minds, since "they belong to the class of facts which serve as the clue to new discoveries." According to modern theories, the higher civilization is ever a growth and an outcome from a preceding lower state; and it is inferred that this progress is visible to us throughout all history and in all the material records of human intellect. But here we have a building which marks the very dawn of history—which is the oldest authentic monument of man's genius and skill, and which, instead of being far inferior, is very much superior to all which followed it. Great men are the products of their age and country, and the designer and constructors of this wonderful monument

could never have arisen among an unintellectual and half-barbarous people. So perfect a work implies many preceding less perfect works which have disappeared. It marks the culminating point of an ancient civilization, of the early stages of which we have no record whatever.

The three cases to which I have now adverted (and there are many others) seem to require for their satisfactory interpretation a somewhat different view of human progress from that which is now generally accepted. Taken in connection with the great intellectual power of the ancient Greeks—which Mr. Galton believes to have been far above that of the average of any modern nation—and the elevation, at once intellectual and moral, displayed in the writings of Confucius, Zoroaster, and the Vedas, they point to the conclusion, that, while in material progress there has been a tolerably steady advance, man's intellectual and moral development reached almost its highest level in a very remote past. The lower, the more animal, but often the more energetic types, have however always been far the more numerous; hence such established societies as have here and there arisen under the guidance of higher minds, have always been liable to be swept away by the incursions of barbarians. Thus in almost every part of the globe there may have been a long succession of partial civilization, each in turn succeeded by a period of barbarism; and this view seems supported by the occurrence of degraded types of skull along with such "as might have belonged to a philosopher"—at a time when the mammoth and the reindeer inhabited southern France.

Nor need we fear that there is not time enough for the rise and decay of so many successive civilizations as this view would imply; for the opinion is now gaining ground among geologists that paleolithic man was really preglacial, and that the great gap—marked alike by a change of physical conditions, and of animal life—which in Europe always separates him from his neolithic successor, was caused by the coming on and passing away of the great ice age.

If the views now advanced are correct, many, perhaps most, of our existing savages, are the successors of higher races; and their arts, often showing a wonderful similarity in distant continents, may have been derived from a common source among more civilized peoples.

I must now conclude this very imperfect sketch of a few of the offshoots from the great tree of Biological study. It will, perhaps, be thought by some that my remarks have tended to the depreciation of our science, by hinting at imperfections in our knowledge and errors in our theories, where more enthusiastic students see nothing but established truths. But I trust that I may have conveyed to many of my hearers a different

impression. I have endeavored to show that even in what are usually considered the more trivial and superficial characters presented by natural objects, a whole field of new inquiry is opened up to us by the study of distribution and local conditions. And as regards man, I have endeavored to fix your attention on a class of facts which indicate that the course of his development has been far less direct and simple than has hitherto been supposed; and that, instead of resembling a single tide with its advancing and receding ripples, it must rather be compared to the progress from neap to spring tides, both the rise and the depression being comparatively greater as the waters of true civilization slowly advance towards the highest level they can reach.

And if we are thus led to believe that our present knowledge of nature is somewhat less complete than we have been accustomed to consider it, this is only what we might expect; for however great may have been the intellectual triumphs of the nineteenth century, we can hardly think so highly of its achievements as to imagine that, in somewhat less than twenty years, we have passed from complete ignorance to almost perfect knowledge on two such vast and complex subjects as the origin of species and the antiquity of man.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Pyrogenic Hydrocarbons in Coal Gas.*—Berthelot has made a study of the hydro-carbons in coal gas, which tends to confirm his theory of the formation of these bodies by the action of acetylene and hydrogen at high temperatures. In the Paris gas for example, he finds that he can detect benzene by exposing two or three cubic centimeters to a drop of fuming nitric acid. On diluting with water, the characteristic odor of nitrobenzene appears. Fifty liters of gas passed through 8 or 10 c.c. of the acid, gives enough nitrobenzene when diluted, to weigh; from which it appears that the gas contains two or three volumes of benzene vapor in the hundred. More accurate determination gives 3 to 3·5 volumes. Next to methane, therefore, benzene is the principal hydrocarbon in this gas and is the illuminant, *par excellence.* Ethylene and acetylene, though present, exist in minute proportion, only two to three thousandths. Propylene, butylene, and allylene are found, in amount about two-tenths per cent. They were detected by passing the gas first through sulphuric acid diluted with its own volume of water, and then through a column of pumice stone wet with concentrated sulphuric acid. A tarry substance collected in the first vessel, which yielded

no products volatile below 360°–400°, and was probably composed of polymers of some easily alterable hydrocarbon. The acid itself, fractionated, gave acetone, 0·25 gram per 100 cubic meters, coming from the hydration of allylene. The sulphuric acid collected beneath the pumice column gave two layers. The lower one consisted of the acid, more or less altered. Diluted with water, a tarry substance of high boiling point separated, probably polymerized hydrocarbons. The acid liquid gave isopropyl alcohol on distillation, thus proving the existence of propylene. The upper layer of liquid, in amount about 25 grams to 100 cubic meters of gas, consisted of hydrocarbons, and gave on fractioning, benzene (with a little toluene) 2 per cent, mesitylene (C_9H_{12}) 5 per cent, cymene ($C_{10}H_{14}$) 20 per cent, tricrotonylene ($C_{12}H_{18}$) 30 per cent, colophene ($C_{15}H_{24}$) 32 per cent, residue fixed at 320° 5 per cent, intermediate products and loss 6 per cent =100. In one million volumes of this gas, consequently, there are by this analysis:

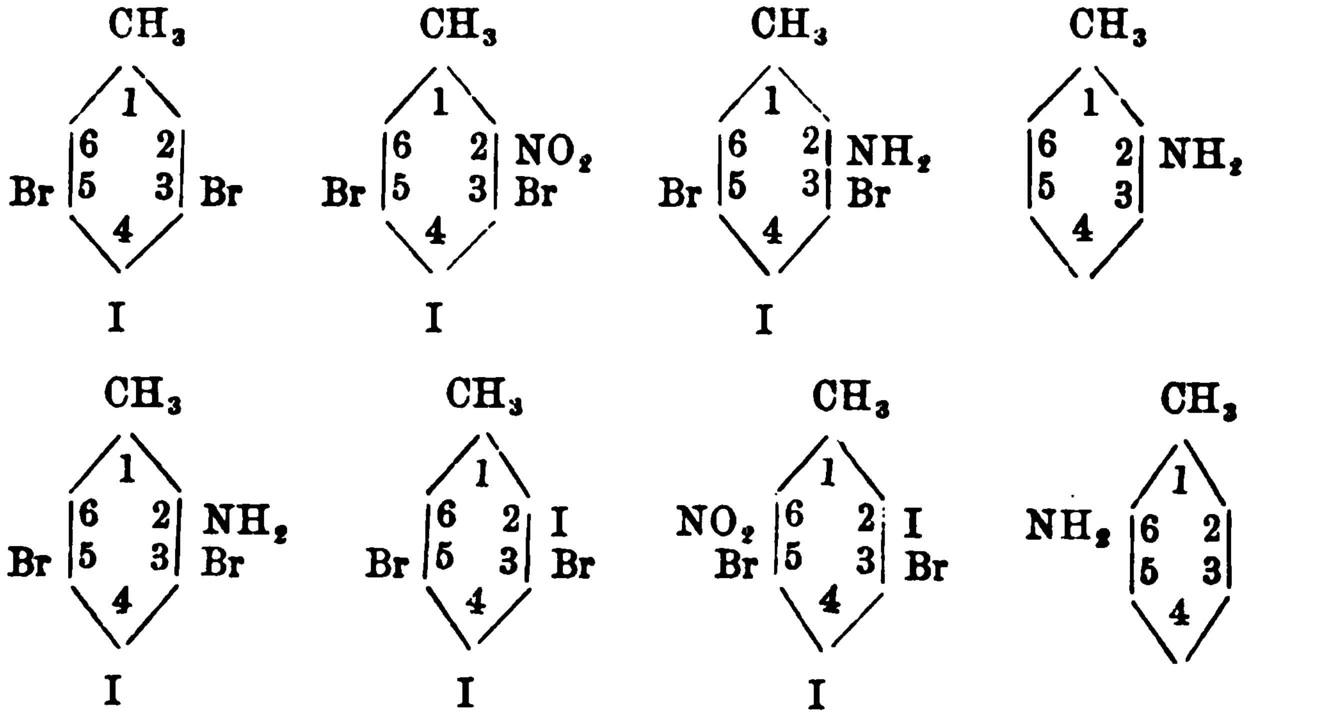
Benzene (C_6H_6) in vapor	30000 to 35000	
Acetylene (C_2H_2)	1000 (about)	
Ethylene (C_2H_4)	1000 to 2000	
Propylene (C_3H_6)	2·5	181
Allylene (C_3H_4)	8	
Butylene (C_4H_8) and analogues	traces	
Crotonylene (C_4H_6)	31	
Terene (C_5H_8)	12	
Hydrocarb's transfor'd into fixed polymers, est'd	83	
Diacetylene and analogous hydrocarbons, est'd	15	

The author regards these products as derived according to the reactions upon which he founds his theory, from the four fundamental hydrocarbons acetylene C_2H_2, ethylene C_2H_4, dimethyl C_2H_6, and methane CH_4. These, together with hydrogen forming a system in equilibrium, such that, at a red heat they are all formed from any one of them as the starting point. Thus from methane comes directly ethylene (C_2H_4) or $(CH_2)_2$, propylene $(CH_2)_3$ and the series of polymers $(CH_2)_n$. Acetylene produces benzene C_6H_6 or $(C_2H_2)_3$, and the series of polymers $(C_2H_2)_n$. Moreover, from the union of two of these fundamental hydrocarbons, more complex bodies come: acetylene and benzene giving styrolene C_8H_8; acetylene and styrolene, naphthalene $C_{10}H_8$; acetylene and naphthalene, acenaphthene $C_{12}H_{10}$; and styrolene and benzene, anthracene $C_{14}H_{10}$. So acetylene combines at a dull red heat with ethylene to form ethylacetylene C_4H_6, and with propylene to yield propylacetylene C_5H_8, the former identical with crotonylene, the latter with terene. The uselessness of the present eudiometric method of determining the illuminants in gas analysis is obvious from these results.—*Bull. Soc. Ch.*, II, xxvi, 104, Aug., 1876. G. F. B.

2. *Occurrence of Benzene in Rosin Oil.*—WATSON SMITH has examined the light oils obtained as a bye-product in the refining

of rosin by distillation in a current of super-heated steam. In 1867, he examined a sample which began to boil at 50° and which distilled almost completely below 100°. On fractioning, a liquid was obtained boiling between 80° and 85° which had the properties of benzene, though contaminated with turpentine-products. Meantime changes had been made in the works, a much higher temperature being employed. A sample from the first run of the rectifying still, examined in 1875, began to boil at 109°, and to condense at 116°. When fractionated, toluene was the substance of lowest boiling point obtained. Hence the temperature of distillation determines the products.—*J. Chem. Soc.*, II, xxx, 29, July, 1876. G. F. B.

3. *On the Constitution of the Benzene Derivatives.*—WROBLEWSKY described in 1875 two metabromtoluenes having identical properties, in one of which the methyl and the bromine atoms occupied the 1 : 3 position according to Kekulé's theory, in the other the 1 : 5 position. He now describes two ortho-toluidines having the methyl and amidogen groups respectively in the positions 1 : 2 and 1 : 6. Starting with dibromparatoluidine, in which the two bromine atoms occupy the positions 3 and 5, the methyl and amidogen groups 1 and 4, the author replaced the amidogen by iodine, thus forming $C_7H_5Br_2I$, dibromparaiodtoluene. By the action of fuming nitric acid a nitroderivative $C_7H_4Br_2INO_2$ was obtained, in which the nitryl must occupy the position 2 or the position 6. On reduction with tin and hydrochloric acid this gave $C_7H_4Br_2INH_2$, and this by the action of sodium amalgam gave orthotoluidine, $C_7H_7NH_2$. For the second substance, the meta-dibrom-paraiod-ortho-toluidine was converted by the method of Griess into $C_7H_4Br_2I_2$ dibrom-diiod-toluene. This gave a nitroderivative $C_7H_3Br_2I_2NO_2$, in which the nitryl must occupy the position 6 if the former had 2; or the reverse. By reducing the amido-product obtained from this with sodium amalgam, a second ortho-toluidine was obtained, identical in properties with the former, thus adding a new confirmation to Kekulé's theory. The progress of the replacements is thus represented:



—*Ber. Berl. Chem. Ges.*, ix, 1055, July, 1876. G. F. B.

4. *On the Action of Malt-extract on Starch.*—O'SULLIVAN has examined more fully the conditions under which malt-extract acts on starch. He formulates his conclusions as follows: (1) Maltose and dextrin are the only products of the action of malt-extract on starch. (2) Cold malt-extract does not act on ungelatinized starch. (3) Malt-extract begins to dissolve starch at the temperature of gelatinization or a few degrees lower. (4) Malt-extract dissolves gelatinized starch in the cold, (10° to 20°) almost completely if the gelatinization be perfect. (5) When starch is dissolved by malt-extract at any temperature below 63°, if the solution be immediately (5 or 10 minutes) cooled and filtered, the product invariably contains maltose and dextrin in proportions agreeing closely with 67·85 per cent of the former, and 32·15 per cent of the latter. (6) If the temperature of the action be between 64° and 68°–70°, the maltose present is 34·54 per cent and the dextrin 65·46 per cent. (7) If the temperature be between 68° and 70° and the point at which the activity of the transforming agent is destroyed, the maltose and dextrin are in the proportion of 17·4 to 82·6 per cent. The decomposition of starch into maltose and dextrin is molecular and takes place according to three equations, corresponding to the conditions in (5), (6) and (7) above. Dextrin is converted into maltose by a slow and gradual process of hydration. —*J. Chem. Soc.*, xxx, 125, Aug., 1876. G. F. B.

5. *Detection of Carbamic acid in Animal fluids.*—HOFMEISTER has examined the evidence upon which Drechsel based his assertion that carbamic acid is produced wherever nitrogenous substances are oxidized in alkaline solutions, and hence exists in the blood. He finds that the reactions upon which Drechsel based his opinion are untrustworthy, inasmuch as the production of a precipitate on boiling, after having filtered off the precipitate produced by calcium nitrate, cannot be taken as proof of the existence of carbamic acid.- *J. pr. Ch.*, II, xiv, 173, Aug., 1876. G. F. B.

6. *Friction of Gases.*—M. WIEDEMANN has measured the changes in the coefficients of friction of gases with changes in the temperature by a new form of apparatus. In a recent paper on the specific heat of gases he claims that a gas undergoes a sort of dissociation upon a change of temperature and that the diameter of the molecules ought not to vary with the temperature according to the same law as if the gas was not decomposed. Moreover, according to the new theory of gases, the coefficient of friction of gases gives a relative measure of the diameter of its molecules. The gas is contained in two glass bulbs 7·3 cms. in diameter and and 4·5 cms. high. One is placed above the other and they are connected by a glass tube ·8 cms. in diameter and 15 cms. long. They are enclosed in a case with glass sides which may be filled with water. Each bulb contains in the prolongation of the tube connecting them, a small orifice. To the lower one is connected a three-way cock with two horizontal tubes. One of these tubes is connected with a reservoir of mercury of variable height, by which mercury may be admitted into the bulbs. The other tube

allows the mercury to pass out. The upper bulb is connected with a water manometer and drying tube and with a capillary tube. The latter is attached to a larger tube 1·8 cms. in diameter and 4·8 cms. long, filled with copper turnings by which the gas is brought to any required temperature before entering the capillary. Both these tubes can be immersed in a vessel of cold water or in a tube with a double wall in which circulates the vapor of aniline or water.

To make the experiment the end of the capillary tube is closed until the top of the mercurial column stands near a point marked on the vertical tube. The capillary is then opened and at the instant the mercury passes the mark, a stop-watch is started and the pressure read by the manometer. This pressure is maintained constant during the whole experiment by slowly raising the mercury reservoir. At the end of 5 to 15 minutes the mercury supply is cut off and that in the bulbs is drawn off until it stands at the level of the mark. The weight of mercury gives the volume of gas transpired. The following table gives the result of the measurement of six gases at temperatures, 8°, 100° and 184·5°. The first column gives the name of the gas, the next three the coefficients of friction at 100° and 184·5° taking the coefficient of air as 100. The last two columns give the friction compared with that of air at 8°.

	0°	100°	184·5°	100°	184·5°
Air	100	100	100	123·1	141·1
Carbonic oxide	96·87	----	96·42	----	136·0
Carbon acid	80·5	85·63	87·50	104·8	123·4
Protoxide nitrogen	80·5	85·82	87·94	105·6	124·1
Ethylene	56·24	60·02	61·93	73·89	87·38
Hydrogen	51·51	51·81			

It is commonly assumed that the friction is proportional to some power n of the absolute temperature. But a computation with the above values shows that no value of n will satisfy all the observations.—*Bib. Univ.*, ccxxiii, 277. E. C. P.

7. *Effect of Sound on the Radiometer.*—M. JEANNEL has observed that certain sonorous vibrations cause rotatory movements in the radiometer. In half obscurity, three radiometers were placed on the interior tablet of a chamber organ. The bass notes, those of the three first octaves, produced rotation, the most bass acting most, but *fa* and *fa* sharp of the lower octave (especially with the bourdon stop) produced more rapid rotation than *ut*, *re* and *mi*, though these are more grave. Radiometers do not all act in the same manner, as to rapidity and direction of their rotation. Thus to the low *fa* or *fa* sharp, radiometer A, the less sensitive to light made about one turn per second. The black faces first (i. e. a direction opposite to that produced by light), whilst radiometers B and C, which were more sensitive to light, turned more slowly in the direction of the movement produced by light. M. Jeannel explains these effects by circular or angular vibrations of the supporting needle transmitted from the tablet of the organ. By applying the finger to the top of the radiometer,

one may prevent the vibration and also the rotation. The board of a piano produces similar effects but in a less degree. If the experiments be made where the diffuse light is nearly sufficient to drive the radiometer, grave sounds, even the weakest, cause rotation in the ordinary direction (bright surfaces first); the rumble of a vehicle will suffice. Here the light is at first insufficient to overcome the friction, but when the vibrations intervene, friction is lessened during certain intervals, and the apparatus is thus rendered more sensitive to light.—*Nature*, xiv, 419. E. C. P.

8. *Fusion of Soft Bodies.*—M. PFAUNDLER has presented to the Imperial Academy of Sciences at Vienna, papers on the nature of the soft or half liquid state of aggregation, and on regelation and recrystallization. After dividing the bodies in question into mixtures of small solid parts with true liquids, soft bodies proper, containing no dissimilar parts, and mixtures of the two classes, he gives a hypothesis on the process of melting and the soft state. The common ideal melting process, when the temperature remains the same from the beginning to the end is not according to fact. The mean temperature of the body beginning to melt is about $t+t'$ lower than that of the already melted mass, if $\pm t$ and $\pm t'$ denote the amounts of divergence of temperature of the separate molecules in the solid and liquid condition. Hence the true melting point is different from that at the beginning, and the end of the melting process. M. Pfaundler extends his hypothesis to soft bodies of a compound nature, and to regelation and recrystallization.—*Nature*, xiv, 383. E. C. P.

9. *Friction of Gases.*—Professor KUNDT, in a popular lecture on "the Modern Theory of Gases," delivered last March in Berlin, made an ingenious application of the principle of the radiometer. Having first shown the friction of air of ordinary density by means of a rotating disk, the lecturer then took an exhausted vessel containing two disks, each about three centimeters in diameter supported very close to one another; the lower one had the usual vanes of the radiometer while the upper one had only a couple of small projecting wires sufficient to show its motion. A magnesium lamp served for projecting the instrument on a screen, and to rotate the lower disk; through the minute amount of air remaining in the vessel the upper disk was put promptly into rotation. Probably the same principle will find other applications when rotation in a vacuum is to be produced. C. K. W.

10. *On the Electro-magnetic action of Electric Convection;* by Dr. HELMHOLTZ. A report on some experiments carried out by Mr. Henry A. Rowland, of the Johns Hopkins University, in Baltimore.—I understand by electric convection the conveyance of electricity by the motion of its ponderable bearers. In my last memoir on the theory of electro-dynamics,* I proposed some experiments (which were then carried out by Herr N. Schiller) in which the question came into consideration whether electric convection is dynamically equivalent to the flow of electricity in a

* *Monatsbericht* of the Berlin Academy of Sciences, June 17, 1875, p. 405.

conductor, as W. Weber's theory assumes. Those experiments might possibly have been decisive against the existence of such an action. They were not so; but, on the other hand, through this negative result the existence of the action in question remained unproved. Mr. Rowland has now carried out a series of direct experiments, in the physical laboratory of the University here, which give positive proof that the motion of electrified ponderable substances is also electro-magnetically operative. I here remark that he had already conceived and fully considered the plan of his experiments when he came to Berlin, without any previous coöperation on my part.

The moved bearer of the electricity was a disk of ebonite 21·1 centims. in diameter and $\frac{1}{2}$ centim. thick. It could revolve with great velocity (up to 61 times in a second) about a vertical axis fixed in its center. The ebonite disk was gilt on both sides; but the gilding was insulated from the axis. Near it, above and below, were placed glass disks of 38·9 centims. diameter, pierced through the middle to admit the axis of the ebonite disk. The glass disks were likewise gilt, in an annular band of 24 centims. external, 8·9 internal diameter; the gilt side was mostly turned toward the ebonite disk. The gilt surfaces of the glass disks were, as a rule, connected to earth; while the ebonite between them, through a point directed toward it at a distance of $\frac{1}{8}$ millim. from its margin, was in electrical communication with the coatings of a large insulated Leyden battery which served as a reservoir for the electricity. A commutator of a peculiar construction, inserted between them, permitted now the one, now the other coating to be connected either with the ebonite disk or with the earth. In the construction of these parts, iron was avoided.

Close above the upper glass disk an extremely sensitive astatic needle was suspended to an arm fixed in the wall, and completely enclosed in a brass case connected to earth. The two needles were 1·5 centim. long, but at a considerable distance (17·98 centims.) from each other. Their deflections were read off with a mirror and a telescope. The opening in front of the mirror was protected from external electrical influences by a metallic hollow cone. Indeed the electrical charge of the battery and the reversal of the electrification of the ebonite disk gave no perceptible trace of action on the needle so long as the ebonite was stationary.

On the other hand, on swift rotation, even without electrifying, the action of rotation-magnetism was shown, mostly arising from the brass axis of the rotating disk, and considerably diminished by reducing it to 0·9 centim. thickness. The action of the electrification of the disk could be separated from that of the rotation-magnetism by letting in alternately positive and negative electricity (by means of the commutator above-mentioned) while the velocity of the rotation was maintained unaltered. The displacement of the needle from the position of equilibrium amounted to from 5 to $7\frac{1}{2}$, its arc of oscillation on changing the electrification, therefore, to from 10 to 15 scale-divisions. This result ensued in hundreds of

observations (which were made with gradually and continually more and more improved apparatus in the course of several weeks), and always in the same direction. The direction of the deflection of the needle, the length of which was normal to the radius of the disk, was such as would have been produced by a positive electric current flowing with the rotation of the positively charged disk, or against the rotation of the disk charged negatively.

There was no alteration in the action when the gilding of the ebonite plate was removed in a series of radial lines, so that annular electric currents could no longer take place. A thin plate of glass was also inserted instead of the gilt ebonite, and, like the disk of a Holtz machine, could be electrified through points; while close beneath it there was a gilt resting plate connected to earth, in order to fix as much electricity as possible. The direction of the deflections was the same as in the previous experiments: but they were smaller, as the conditions were not so favorable for strong electrification.

In order to compare the electricity carried forward by convection with that which passes in conductors, experiments were instituted in the following manner.

The ebonite disk was gilded afresh, and the gold coating divided, by a series of fine circular lines, into rings insulated from one another. The innermost ring was connected with the axis; the rest could not at any rate become considerably charged without discharging themselves by very short sparks from one to the other. Two electrified plates, each having the form of a sector of a circle, but which did not reach to the axis, were placed, opposite to one another, above and below the rotating plate. Under these circumstances the electricity of the gold rings must have been accumulated by electrostatic induction in the sector covered by the last-mentioned plates, and carried forward convectively. When this electricity was positive, it became free at the fore margin of the induced sector (in the direction of the rotation), while at the hind margin of the same, continually new positive electricity being attached, relatively negative electricity became free.

The positive electricity must, under these conditions, have overflowed from the fore to the hind margin of the sector, for which there were in each ring two paths open, between which it must have divided itself in the inverse ratio of their resistances. If the inducing sector comprises $\frac{1}{n}$ of the circumference, the resistance of the path in the sector is to that of the path outside of it as $1 : n-1$; and therefore $\frac{n-1}{n}$ of the current returns through the sector, and $\frac{1}{n}$ outside of it. In the sector a quantity corresponding to the sum of the two currents is carried forward against the current by convection. If, then, a convective motion of electricity

acts like a conducted motion, the total motion in the sector is $1-\frac{n-1}{n}=\frac{1}{n}$. But if the action of convective had been greater or less than that of conducted motion, the excess, in one or the other direction, must have been shown on the sector.

The experiments showed that, when the sector was small ($\frac{1}{8}$ of the circumference), the small difference between the convection 1 and the conduction $\frac{7}{8}$ in general could not (or at least not with certainty) be detected, that therefore, with approximate equality of convection and conduction, the electro-dynamic effect of the one sensibly neutralized that of the other.

When, however, the sector took in half of the circumference, the here assumed current could be observed even in the free portion of the disk, though the amount was too small for safe measurement.

The observed electro-dynamic action being so little in the foregoing experiments, in which the disk was electrified and covered in its whole extent by the induced plates, theoretical calculation of the amount of the action from the known absolute values of the electro-dynamic constants promised only approximately accordant values. Nevertheless it was carried out by Mr. Rowland.

The proportion in which the action of the earth's magnetism upon the pair of astatic needles was diminished was ascertained by finding the oscillation-period, first with the needles equally directed, and then arranged astatically.

The value of the function of the electric potential in the Leyden battery, and on the rotating disk, was determined according to the law of spark-length given by Sir William Thomson, which in this case appeared sufficiently accurate. Before and after each experiment, a smaller jar was charged from the battery of nine large ones containing the store of electricity, and on it the length of the spark was determined.

The velocity of the rotation was regulated by the position of the balls of a centrifugal governor, which was applied to one of the more slowly rotating axes. The calculation from the magnitude of the rollers agreed well with the determination by the tone of a siren-disk, which was for some time attached to the most rapidly revolving axis.

In the calculation of the distribution of the electricity on the disk, and its electro-magnetic directing-force, the surplus charge present at the margin of the disk was reckoned according to the value which holds for infinitely thin disks, and considered as an infinitely thin thread concentrated at the margin—a proceeding which was in both ways only approximately correct, but, in presence of the minuteness of this portion, was sufficient.

The influence exerted upon the upper needle was about $\frac{1}{50}$ of that upon the lower. The horizontal force of the earth's magnetism was put equal to 0·182 (using the centimeter, gram, and second as units): the electro-dynamic constant was put by Mr.

Rowland, after Maxwell's determinations, equal to 28,800 millions. W. Weber's value would be 31,074 millions. I give below under M. the results calculated with the former value, under W. those calculated with the latter.

The following is the result of the calculation of only three series of experiments conducted under favorable circumstances:—

(1) Ten experiments with alternately opposite rotation. In each, three readings, of which the middle one was made with the electrification of the disk opposite to that of the first and third.

Mean difference of the position of equilibrium, in scale-divisions	6·735
Spark-length	0·2845
Electro-dynamic force acting on the astatic pair—observed	0·00000327
" " " " calculated, M.	0·00000337
" " " " " W.	0·00000311

(2) Four experiments, the same.

Difference of the position	7·50
Spark-length	0·2955
Electro-dynamic force—observed	0·00000317
" " calculated, M.	0·00000349
" " " W.	0·00000322

(3) Five experiments, the same.

Difference of the position	7·60
Spark-length	0·2926
Electro-dynamic force—observed	0·00000339
" " calculated, M.	0·00000355
" " " W.	0·00000328

The accordance may be looked upon as satisfactory in the measurement of a force which amounts to only $\frac{1}{50000}$ of the force of the earth's magnetism, since in two of the series the observed values fall between those corresponding to the different measured values of Weber's constant.

As regards the signification of these experiments for the theory of electro-dynamics, they correspond to the hypotheses of the theory of W. Weber; but they can also be referred to Maxwell's, or to the potential-theory which takes account of the di-electric polarization of the insulators. The volume-elements of the stratum of air situated between the resting and the moved plates suffer continual displacements in the direction of a rotation round radially directed rotation-axes. The existing di-electric polarization of these elements will therefore in each material element continually change, while retaining in space the same direction normal to the surface of the electrified disks. The arising and disappearing components of this polarization would constitute the current which is indicated by the astatic pair of needles.—*Monatsbericht der kön. preuss. Akademie der Wissenschaften zu Berlin*, 1876, pp. 211–216; *Phil. Mag.*, Sept. 1876.

II. Geology and Mineralogy.

1. *Note on specimen of Metadiabase from Connecticut Lake, collected and sliced by G. W. Hawes.*—The fragments, apparently organic, in this slice agree with that figured by Mr. Hawes in the August number of the American Journal of Science, Plate v, fig. 5. They consist of a transparent brownish substance, traversed by parallel bars or ribs of greater transparency. In places the bars are interrupted abruptly, and crossed by similar bars nearly at right angles to the others. Between the longitudinal bars are irregular transverse and oblique lines; but these are not properly structural, and appear to be cracks, some of which are open and transparent, but the greater part closed and of a black color. From the irregular shape of the fragments, and the manner in which the ends project in shreds, it is to be inferred that the substance, if organic, was not hard or stony like a coral, but tough and soft, and in an advanced stage of decay. Fragments of the horny investment of Hydroids or Bryozoans might present such appearances, and in this case the planes where the bars are interrupted may represent the mouths of cells. Again, the chitinous crust of some Entomostracans, as for example, species of *Dithyrocaris*, shows bands not very dissimilar from those in the fragments, which, however, present no trace of the cellular structure usual in such crusts. Again, the Devonian plants of the genus *Dictyophyton* show a rectangular areolation which, though much coarser, reminds one of these specimens. Lastly, Gumbel has figured from the Laurentian of Bavaria certain films with rectangular meshes, much finer than those of Mr. Hawes' specimens, but not unlike them in appearance, and which he regards as organic. On the whole, though these objects are unlike any purely mineral substance with which I am acquainted, and are probably fragments of some organic body, I do not think it possible at present to indicate with any certainty their probable affinities.

Sept. 7, 1876. J. W. DAWSON.

2. *On Streams of Water beneath Glaciers.* — Mr. Charles Knight, in the Philosophical Magazine for June, states that, according to Professor Wm. Thomson's experiments, the freezing point of water is lowered 0°·23 F. for each additional atmospheric pressure; and that, hence, if a glacier have a thickness of 3,000 feet, the pressure would be about 80 atmospheres, and under this pressure the temperature at the base should not exceed 13° F. to retain the solid form. The statement needs a correction, since Professor Wm. Thomson's experiment made the lowering of the freezing point of water 0°·23 F. for *sixteen* atmospheres of pressure. This would give for 80 atmospheres, supposing the increase by arithmetical ratio, only 1°·15 F.

3. *Quinto Apendice al reino mineral de Chile i de las Republicas vecinas publicado en la segunda edicion de la Mineralojia de don* Ignacio Domeyko. 79 pp. 8vo. Santiago, 1876.—The fifth

Appendix by Domeyko to his Mineralogy of Chili follows the fourth after an interval of two years. It contains much valuable and interesting matter, including the description of the following new minerals:

Daubreite.—Amorphous. In structure earthy and compact, in parts fibrous. H.=2·5. G.=6·4–6·5. Color yellowish to grayish-white. Opaque. An analysis gave Bi_2O_3 89·60, Cl 7·50, H_2O 3·84(?), Fe_2O_3 0·72, which corresponds to the formula $(Bi_2O_3)_4$, Bi_2Cl_6. This formula places the mineral in the series with the two artificial compounds $(Bi_2O_3)_2$, Bi_2Cl_6, and $(Bi_2O_3)_6$, Bi_2Cl_3. It is easily soluble in hydrochloric acid, without residue. Locality, Constancia Mine, Cerro de Tazna, Bolivia.

Krönkite.—In irregular crystalline masses with coarse fibrous structure; probably triclinic. Cleavage distinct parallel to an edge of the prism. Color azure-blue, changing somewhat on exposure to the air. Luster vitreous; translucent. Composition $CuSO_4+Na_2SO_4+2H_2O$, which requires $CuSO_4$ 47·23, Na_2SO_4 42·09, H_2O 10·68=100. Perfectly soluble in water. Found in the copper mines near Calama, on the road from Cabija to Potosi, Bolivia.

Phillipite.—Forms small irregular masses and bands in the same argillaceous ochre in which the copper pyrites occurs, by the decomposition of which it has been formed. Structure fibrous, sometimes compact; never prismatic like Krönkite. Color azure-blue. Luster vitreous; translucent. Soluble in water, but unaffected by exposure to the air. Composition $CuSO_4+FeS_3O_{12}+$ n *aq*. Analysis gave SO_3 28·96, FeO_3 9·80, CuO 14·39, MgO 0·85, H_2O 43·72 AlO_3 *tr*=100·00. Found at the copper mines in the Cordilleras of Condes, Province of Santiago, Chili.

Huantajayite.—Isometric. Crystallizes in cubes like the chlorides of sodium and silver. H.=2. Transparent. Color white, not altered by exposure to the air. Fragile, easily reduced to a powder, not sectile like cerargyrite. Composition 20NaCl+AgCl; an analysis gave NaCl 89, AgCl 11=100. B.B. decrepitates and fuses easily, losing its transparency; with soda yields metallic silver. Found at the mine of San Simon, in the Cerro de Huanjayita.

The descriptions of the following new minerals in the Appendix are given by Sr. Raimondi.

Cuprocalcite.—Occurs in small masses, and in bands intimately mixed with a ferruginous carbonate of calcium. H.=3; G.=3·90. Color bright vermillion-red. The analysis gave Cu_2O 50·45, CaO 20·16, CO_2 24·00, H_2O 3·20, FeO_3 0·60, AlO_3 0·20, MgO 0·97, SiO_2 0·30=99·88. This leads to the formula $(Cu_2O)_2CO_2+2CaCO_3+H_2O$, which requires Cu_2O 52·2, CaO 20·4, CO_2 24·1, H_2O 3·3=100. Soluble in hydrochloric acid with effervescence. The solution, formed with exclusion of the air, has a strong deoxydizing power, precipitating metallic gold from solutions of gold salts. Found at the mines of Canza, near the city of Ica, in Peru.

Werthemanite.—Occurs in powder, or in masses easily reduced to powder. Color white. Gives an argillaceous odor, and adheres

to the tongue. G.=2·80. Soluble only in sulphuric acid. An analysis gave SO_3 34·50, AlO_3 45·00, FeO_3 1·25, H_2O 19·25=100. This affords the formula $AlSO_6+3H_2O$; or like aluminite except in the smaller amount of water. Found near the city of Chachapoyas.

Malinowskite.—A variety of tetrahedrite. An analysis of the mineral from the district of Rocuay gave S 24·27, Sb 24·74, As 0·56, Pb 13·08, Cu 14·37, Ag 11·92, Fe 9·12, Zn 1·92=100. Other analyses of the same mineral from the mine of Carpa agree closely with this. It occurs massive, and has a gray color and metallic luster. E. S. D.

III. Botany.

1. *Flora of British India;* by J. D. Hooker, C.B., &c. Part IV. pp. 240. Date of issue not given.—This commences the second volume and contains the orders *Sabiaceæ*, *Anacardiaceæ*, and *Connarceæ*, by Dr. Hooker, and the *Leguminosæ* down to the genus *Derris* (two thirds of the 132 genera), by Mr. Baker. The model of the British Colonial Floras is followed. It is curious to find our *Clitoria Mariana* as an Indian species. A. G.

2. *Compositæ Indicæ descriptæ et secus Genera Benthamii ordinatæ*, a A. B. Clarke. Calcutta, Thacker, Spink & Co. 1876. pp. 347, xlv, 8vo, 1876.—This important side-contribution to the Indian flora is in Latin, but otherwise on nearly the plan of the Flora of British India, except that the generic characters are wholly given in the conspectus; and it is supplemented by copious tables of geographical distribution. The whole appears to be very well done, and, being published at the author's own expense, the cordial thanks of botanists are justly due. A. G.

3. *Proceedings of the American Association for the Advancement of Science, 24th meeting*, 1875. Botanical Articles.—These are few, occupying only 20 pages of the thick volume, and are not of high importance. The longest is that in which Mr. Meehan asks the question "*Are Insects [of] any material aid in fertilization*" of flowers? He answers the question in the negative, but not to our satisfaction. Some of the facts are open to question, or would take in other hands a different interpretation; and several of the illustrations of supposed self-fertilization are from flowers in which other observers, with opposite prepossessions, see exquisite adaptation to crossing. As we may not ourselves rightly appreciate Mr. Meehan's ingenious argumentation (our own observations all pointing to an opposite conclusion) we state that he claims to have proved:

"First, that the great bulk of colored-flowering plants are self-fertilizers.

"Secondly, that only to a limited extent do insects aid fertilization.*

* *Apropos* to Mr. Meehan's suggestion, that, although the alpine plants of the Colorado Rocky Mountains are mostly highly colored, insects are there so rare that they can be of no material aid to fertilization, and therefore these plants must self-fertilize, it may not be amiss to introduce testimony. An entomologist now

"Thirdly, that self-fertilizers are every way as healthy and vigorous, and immensely more productive than those dependent on insect aid.

"Fourthly, that where plants are so dependent, they are the worse fitted to engage in the struggle for life."

It is not easy to perceive how the last two very comprehensive propositions are or can be demonstrated.

The next article, on *Carnivorous Plants*, by Professor Beal, of Michigan, is short and sketchy, recapitulating some facts well-known in the science, though novel to a popular assemblage; and finally, referring to *Martynia* and the vast number of small insects which are caught by its sticky glands, he suggests that "it is a true insectivorous plant." That may well be; but the observations and experiments recorded were not carried to the point of proving it, although this might not have been very difficult.

Inequilateral Leaves, by the same author, is a brief article, detailing a good number of cases, and ending abruptly with the remark: "Why these leaves have unequal lobes I cannot see; and I have no theory to offer as a probable explanation."

The Venation of a few odd Leaves, also by Professor Beal, is a short note, in which the main point is a curious suggestion as to the morphology of the odd leaf of the Ginkgo tree.

Some Observations on the structure and habits of Utricularia vulgaris, by T. B. Comstock, is an abstract merely, describing the apparatus and apparent action of the bladders. "The value of this paper is slight, except as confirmatory, in a measure, of the discoveries of others, and as an illustration of the great ease of conducting similar observations, now much needed."

Lastly, *Periodicity in Vegetation*, by James Hyatt, of Dutchess Co., N. Y., is a longer article, noting how certain plants appear and disappear in different years, in certain places, *Silene antirrhina*, for instance, abounding in 1864, 1869, and 1874, "while not a single plant has shown itself, neither in 1875, nor in any other year than those specified since 1864;" from which it would appear that "the seeds lie dormant through the intermediate period." The article concludes with some noteworthy suggestions and plans for the convenient keeping of a useful botanical diary, especially for the recording of periodical phenomena. A. G.

at my side, who has passed four summers among these mountains and made frequent visits to the alpine regions, informs me that he has "always found insects of all orders quite abundant in the Rocky Mountains, and especially so wherever flowers occur in most variety, as in the immediate vicinity of the timber-line, 10,000 to 12,000 feet," etc. Also that "insects are much more abundant everywhere in the mountains than on the plains." He has "frequently noticed the congregation of butterflies, in considerable numbers, about the bleak and barren summits of rocky peaks far above the timber-line, whither they had probably been drifted by the wind. Bees and other Hymenoptera occur in considerable variety and abundance at the timber-line. In fact, one of the best places for collecting them is among the vast fields of flowers which there occur." Finally he remarks that "although, as a rule, insects, as well as other animals, are not so plentiful in all the Rocky Mountains as in many other parts of the country, yet, comparing the alpine regions with the plains, I have always found insects *very much* more abundant in the former than in the latter." A. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Prof. Huxley in New York.*—Three lectures on Evolution were delivered by Prof. Huxley to a very large and interested New York audience during the week which closed with his departure for England. He appealed chiefly to American facts in his lucid and well-conducted argument, and especially to those which had been gathered by Prof. Marsh, whose "enormous collections" in the Yale Peabody Museum he had examined a few weeks before. Respecting these collections he remarked: "I can emphatically say that so far as my knowledge extends, there is nothing in any way comparable to them for extent, or for the care with which the remains have been collected, or for their scientific importance in the series of fossils." The Cretaceous birds with teeth—Marsh's Odontornithes—and also the Dinosaurs (whose tracks he had seen in large numbers during an excursion under Prof. Marsh's escort to Greenfield, Massachusetts), were referred to at length in the second lecture, and the series of horses from the American Tertiary, in the third. Prof. Huxley closed as follows: "I did not, when I commenced this series of lectures, think it necessary to preface them with a prologue, such as might be expected from a stranger and a foreigner; for during my brief stay in your country I have found it very hard to believe that a stranger could be possessed of so many friends, and almost harder to imagine that the foreigner could express himself in your language in such a way as to be so readily intelligible to all appearance; for, so far as I can judge, that most intelligent and perhaps I may add most singularly active and enterprising body of the press, your press reporters, do not seem to have been deterred by my accent from giving the fullest account of everything that I happen to have said. [Great applause.] But the vessel in which I take my departure to-morrow morning is even now ready to slip her moorings; I awake from my delusion that I am other than a stranger and a foreigner. I am ready to go back to my place and country, but before doing so, let me, by way of epilogue, tender to you my most hearty thanks for the most kind and cordial reception which you have accorded to me; and let me thank you still more for that which is the greatest compliment which can be afforded to any person in my position—the continuous and undisturbed attention which you have continued to bestow upon the long argument I have had the honor to lay before you."

2. *The Eighth Annual Report of the Department of Marine and Fisheries of Canada*, containing the Report on the Meteorological and other Observatories, for the year 1875, has recently come to hand. The Canadian office, like that of our own army, contemplates both the study of climatological statistics, and the practical utilization of meterology especially in the prognostications of the weather. Its stations are classified as the central office, ordinary stations, chief stations, reporting telegraph stations, and

publishing telegraph stations. Thirteen Canadian stations send tri-daily reports to the central office at Toronto, whence they are telegraphed to Washington. At 36 stations storm warning signals, generally as suggested by telegraph from Washington, are displayed by hoisting the storm drum; 628 warnings were issued on 55 days in the course of 1875. For those stations from which reports have been published, about 80 per cent are reported verified.

The simultaneous observations at the Canadian stations are printed in full as a part of Professor Kingston's report, followed by the monthly, quarterly and annual averages of meteorological elements and other tabular matter.

In the report of the Director of the Magnetic Observatory at Toronto, it is stated that the Kew System of self-recording apparatus has been adopted there with considerable success. At the Montreal Observatory it is stated that the anemometer by Green is furnished with a self-recording attachment as made by Hahl & Co., of Washington. At Quebec, the noon-day time-gun has been fired daily by electricity, the machinery having worked with great satisfaction. The director of this observatory, Lieutenant E. D. Ashe, hopes that the observatory will soon take a prominent place in the study of physics. At St. Johns, New Brunswick, the noonday time-ball, which is on the Custom House building, is dropped by the director in charge of that duty.

In singular contrast with the appreciation shown by the Canadian authorities of the importance of distributing accurate time to the shipping, is the utter neglect of the subject shown in the United States, where shipmasters are obliged to obtain accurate time, before leaving port, by application to some clock-maker, whereas the Naval Observatory at Washington might easily be authorized to furnish official standard time to the whole country.

C. A.

3. *British Association.*—Extended reports of the Glasgow meeting of the British Association are published in Nature, commencing with the number for September 7th (No. 378). The address of Sir William Thomson and Mr. Wallace, forming articles in this number, have been copied from that Journal. According to a note by Mr. Wallace, later published, *Kerguelen's Land*, p 368, second line from foot, should be *Tristam d'Acunha.*

4. *Diatoms in Wheat Straw.*—The article on this subject, by Professor P. V. Wilson, in the last volume of this Journal (p. 373), has, with good reason, encountered doubts and criticisms in other journals, both at home and abroad. After its publication, when it first met the eye of our botanical editor, he wrote us at once, pronouncing the alleged facts intrinsically absurd; and, in a subsequent number of the Journal, alluded to the mistake into which he supposed the writer of the article had honestly, but ignorantly fallen. An examination of the figures of the "Forms of Diatoms found in Col. Kunker's Straw"—reproduced with severe strictures, in the American Journal of Microscopy—has led him to write us further that his explanation can apply only to a few of the figures, and that the charitable construction must be withdrawn.—Eds.

APPENDIX.

ART. XLII.—*Notice of new Tertiary Mammals.* V; by Professor O. C. MARSH.

THE remains here described are from the Eocene of the Rocky Mountain region. They include a new genus of Equine mammals, allied to *Orohippus*, but an earlier and less specialized form, apparently in the direct ancestral line, and hence of much interest. All the specimens described are preserved in the Museum of Yale College.

Eohippus validus, gen. et sp. nov.

This genus is very nearly related to *Orohippus*, but may be readily distinguished from it by the dentition, the last premolar above and below being similar to the next premolar in front, and not like the adjoining true molar, as in *Orohippus*. In other respects, the teeth in the two genera are very much alike, and the dental formula is the same for both. The feet, also in their main features, are very similar, there being in each genus four well developed toes in front and three behind, but *Eohippus* has a rudiment of the outer, or fifth, metatarsal, and may have had a similar remnant of the first digit in the fore foot. The radius and ulna, and the tibia and fibula were distinct, and entire, and in most other respects the skeleton resembled that of *Orohippus*.

The present species is based mainly upon a fragmentary skeleton, with the principal teeth well preserved. These remains indicate an animal about as large as a fox, but of rather more robust proportions. Some of the more important measurements are as follows:

Extent of three lower true molars	25·4 mm.
Antero-posterior diameter of last lower molar	11·2
Transverse diameter	5·4
Antero-posterior diameter of last lower premolar	7·
Transverse diameter	5·4
Antero-posterior diameter of first upper true molar	7·
Transverse diameter	9·5

The known remains of this species are from the *Coryphodon* beds, or lowest Eocene. of New Mexico. This horizon is below that in which *Orohippus* occurs.

Eohippus pernix, sp. nov.

A smaller species of the same genus is indicated by fragmentary remains of several individuals. Most of these fossils are in excellent preservation, and among them are some of the most characteristic portions of the skeleton. The distal end of the tibia is remarkably like that of the modern horse. The astragalus, also, is quite equine in type, but the anterior portion is more elongated. It has a small facet for the cuboid, as in the horse. The molar teeth are similar in pattern to those of *Orohippus*.

The following are some of the principal measurements:

Extent of three lower true molars	20· mm.
Antero-posterior diameter of first lower true molar	6·
Transverse diameter	5·
Depth of lower jaw below first true molar	11·
Antero-posterior diameter of distal end of tibia	13·
Transverse diameter	10·
Length of astragalus	15·5
Transverse diameter in front	10·

The remains here described are from the *Coryphodon* beds, or lowest Eocene, of Wyoming.

Parahyus vagus, gen. et sp. nov.

An interesting genus of suilline mammals is represented by a nearly perfect lower jaw and a few other remains in the Yale Museum. This jaw, which has most of the teeth well preserved, shows a near affinity to *Elotherium* Pomel, and to *Helohyus* Marsh, but it may easily be separated from those genera, as it has one less premolar. It differs from the former genus, moreover, in its last lower molar, which has a well developed posterior lobe. In other respects, the teeth are very similar to those of *Elotherium*. The present genus affords an interesting example of an extinct form outside of the ancestral line which terminated in existing suillines. A similar example is seen in *Anoplotherium*.

The specimens preserved pertained to an animal about the size of a modern wild boar, but the jaws were proportionately shorter and stouter. The canine was large, and the three premolars were all compressed, and each had two roots.

The dimensions of this specimen are as follows:

Extent of six molar teeth	138· mm.
Antero-posterior diameter of last lower molar	34·
Transverse diameter	17·
Antero-posterior diameter of first true molar	19·
Transverse diameter	13·
Depth of lower jaw below first true molar	46·

The only specimens of this species now known are from the lower Eocene of Wyoming.

Dromocyon vorax, gen. et sp. nov.

A new and remarkable carnivorous mammal about the size of a large wolf is represented in the Yale Museum by a nearly complete skeleton In the form of the skull, and general character of the jaws and teeth, the genus resembles *Hyænodon*. In the present specimen there were apparently but two lower incisors in each ramus. There are seven lower molar teeth, and the last lower molar is small. The top of the skull supported an enormous sagittal crest. The brain was small and convoluted. The lower jaws are long and slender, and the condyles low.

The femur has a small third trochanter and the astragalus a facet for the cuboid. There were but four toes in front, and four behind.

Some of the more important dimensions of this skeleton are as follows:

Length of skull from occipital condyles to front of premaxillaries	280·mm·
Distance from foramen magnum to top of sagittal crest	80·
Extent of lower molar series	131·
Extent of three true molars	70·
Antero-posterior diameter of last lower molar	15·
Transverse diameter	9·
Length of third metacarpal	78·
Length of third metatarsal	88·

The remains of this species at present known, are from the Eocene of Wyoming.

Dryptodon crassus, gen. et sp. nov.

The present genus belongs in the order *Tillodontia*, and is apparently most nearly allied to *Stylinodon*. It is based upon the nearly perfect lower jaws, with most of the teeth preserved, and some fragmentary remains of the skeleton of the same individual. These. specimens indicate an animal nearly as large as a Tapir. The lower jaws are very short, and massive, especially in the anterior portion. In each ramus there were ten teeth, forming a continuous series. Three of these are clearly incisors, the two anterior being small and cylindrical, and the outer one of enormous size, compressed, faced in front with enamel, and growing from a persistent pulp. Next to this, was a small tooth which may have been a canine, and immediately behind this a series of six similar molars. The latter are cylindrical, and their sides nearly or quite covered with enamel. Three are apparently premolars, and the large incisor extends beneath them.

The principal measurements of this specimen are the following:

Extent of dental series	135· mm.
Extent of six lower molars	95·
Antero-posterior diameter of large incisor	37·
Transverse diameter	17·
Antero-posterior diameter of last premolar	16·
Transverse diameter	15·
Depth of lower jaw below canine	80·
Depth below first molar	60·
Depth below last lower molar	50·

The specimens above described are from the lower Eocene of New Mexico.

Yale College, New Haven, Oct. 23, 1876.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLIII.—*Experiments on the nature of the force involved in Crookes' Radiometer*; by Prof. O. N. ROOD, of Columbia College.

IT is impossible for a physicist to regard the little instrument devised by Mr. Crookes with other than a feeling of unusual interest, based partly on the performance of the apparatus itself, and partly on possible applications which immediately suggest themselves. The explanation of these curious phenomena offered by Ronalds, and afterward more in detail by Stoney,* together with the confirmatory experiment of Schuster, led me to devise two new methods for still farther testing the theory thus advanced, and to make at the same time an examination of the phenomena when the suspended discs were under the ordinary atmospheric pressure.

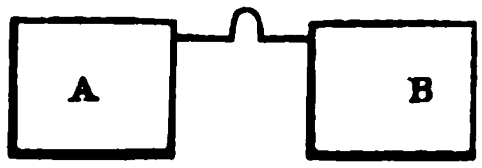
The explanation offered by Stoney is based on the mechanical theory of gases, and reaches the final result that a reaction takes place between the blackened sides of the movable vanes and the glass envelope, so that there is a tendency for them to recede from each other. I first arranged an experiment so that I could at will destroy the possibility of this reaction taking place, without interfering with the other necessary conditions.

Description of the apparatus.—Two discs of thin aluminium foil, A and B, fig. 1, the same in size, were prepared, and

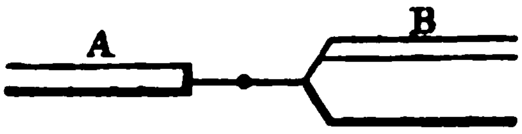
* On Crookes' Radiometer; G. Johnstone Stoney, Phil. Mag., March and April, 1876.

blackened, each on one side, with lampblack to which a minute portion of spirit varnish had been added. Each disc was folded so as to be double, the two leaves not being in contact. Disc B carried in front of it a plate of mica equal in size with itself, and distant from it about 5 mm. The system was arranged so as to be capable of suspension by a single fiber of silk, and was provided with a small directing magnet. Fig. 2 gives a view of the arrangement from above.

1.



2.



The discs thus arranged were enclosed in a clear glass flask, which was exhausted to a pressure of ·25 of a millimeter and sealed up.

The flask with its contents was then placed on a graduated circle and centered. The deviations of the disc were observed by a compound microscope of low power, which was capable of independent rotation about the axis of the circle. It was provided with an index with which tenths of degrees could readily be estimated, the circle itself being divided into half degrees. The small magnet connected with the discs was rendered nearly astatic by an external magnet: it consumed thirty-two seconds in making a single oscillation.

Experiments.—The light of a luminous gas-flame at a distance of twelve inches was allowed to fall on the blackened disc not provided with a plate of mica, its companion being protected by a triple screen of sheet brass from the action of the flame. Under these circumstances the exposed disc moved away from the light: after it had come to rest ten readings were made; below is the result obtained by two such experiments:

3°·06
3°·40

3°·23 mean deviation away from light.

Next, the vane provided with the mica shield was exposed, the other being screened. After a slight agitation it came to rest, and ten readings were made as before; the results of two experiments are given below:

0°·26 away from light.
0°·06 toward the light.

0°·10 mean.

It will be seen that the interposition of the mica plate attached to the vane actually did prevent any reaction from taking place between the disc and the walls of the flask, so that prac-

tically the disc remained immovable. In the next experiment the brass screen was entirely removed, and the light allowed to fall on both discs simultaneously, a plate of mica, identical in substance with that attached to the vane, being placed outside of the flask and opposite the unprotected vane, so that both vanes received the same amount of radiation, the only difference being that one of them was deprived of its direct communication with the walls of the flask. Under these circumstances the disc without the attached mica screen moved instantly away from the light, as was shown by two careful experiments:

$$\left.\begin{array}{l}2^\circ{\cdot}42\\2^\circ{\cdot}34\end{array}\right\}\text{away from light.}$$

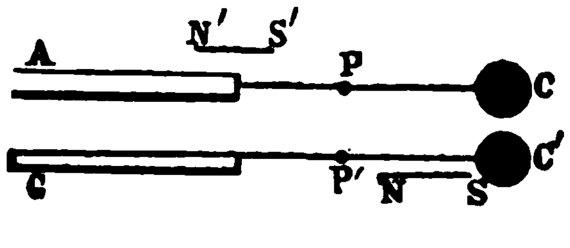
$$\overline{2^\circ{\cdot}38}\ \text{mean.}$$

These results I regard as confirmatory of the theory advanced by Stoney, and as fatal to the idea that the motion is directly dependent on the impact of light or heat, for both discs received the same amount of heat and light.

According to the theory just referred to in these experiments repulsion took place between the blackened disc and the mica attached to it, but being firmly fastened together, no motion of either could result. Assuming this repulsion to exist I devised an apparatus for making it evident and for measuring its amount.

Description of Apparatus.—A disc of aluminium, folded double and blackened on one side, was provided with a small magnet, and suspended by a single fiber of silk in the interior of a glass flask. In front of this was similarly suspended a disc of glass such as is used for covering microscopic objects; it also was provided with a small magnet and both discs were properly counterpoised. These discs were each seventeen millimeters long, and fourteen millimeters high: the weight of each was 0·3 gram, and the minute magnets attached to them were of nearly equal strength. The distance of the points of suspension apart was five millimeters. Figure 3 furnishes a view of the system seen from above.

3.



A is the aluminium disc, G that of glass, P and P′ are the points of suspension, C and C′ the counterpoises, which being on different levels readily passed each other; and N S and N′ S′ are the controlling magnets. The exhaustion of the flask was carried to 0·24 of a millimeter.

Experiments.—It will be observed that the magnets were so arranged as to tend to cause the discs to touch each other, but

in ordinary daylight, or even in feeble daylight, the repulsion was so strong as to cause the discs to assume a parallel position, or even to diverge several degrees. They could not be brought into contact even by covering the flask with white writing paper, but paper thickly painted with lamp black always caused contact in a few minutes. When this apparatus was placed in a darkened room, and suddenly exposed to a luminous gas flame sixteen inches distant, the discs instantly diverged, right and left, with sensibly equal velocities, and after some slight oscillation came to rest. Below are given the final deviations in two trials; five readings being taken in each experiment.

Aluminium.	Glass.
12°·97	8°·36
12°·55	8°·43

Taking the mean of the two experiments, and calling the deviation of the aluminium 100, that of the glass is 65·7. The results just given are sufficiently concordant, and could have been obtained repeatedly without greater variation; still, owing to slight defects of workmanship in the apparatus, I do not lay any great stress on them, further than to prove that both discs are deflected, and that the deflection of the glass disc toward the light is somewhat less than that of the aluminium away from it. In another experiment with a similar apparatus, it was found that if the deviation of the aluminium was taken as 100, that of the glass was 74·8.

The result of this experiment, is, as it seems to me, absolutely fatal to any theory which assumes that the repulsion in a Crookes' radiometer is due to the direct impact of heat or light, and I think also it cannot well be explained by assuming the existence of ordinary convection currents.

Experiments under the full pressure of the atmosphere.—Being anxious to make some experiments under the ordinary atmospheric pressure, I arranged a blackened disc of aluminium foil, composed of two laminæ, counterpoised, provided with a small magnet, and suspended by a single fiber of silk in a glass flask. The time of oscillation of the system I could not determine, owing to friction against the air, but judge that it was between thirty and forty seconds. This apparatus was centered on the graduated circle, and the disc observed as before with a compound microscope. It was soon ascertained that the observer exercised, apparently, an attraction on the suspended disc, even when seated nearly in its prolongation; it followed and pointed toward the observer sitting at a distance of little less than a meter with considerable promptitude, being thus deflected from

its true position as much as 20°. The cause of this phenomenon I take to be, that the dark heat from the face of the observer warms mainly that part of the flask directly opposite him; this causes a feeble ascending current of air in that region, and this again a horizontal current toward the heated wall, the latter current acting on the disc precisely as the wind does on a weather-cock. The deflection from this cause was pretty constant, and did not prevent qualitative observations from being made, though in the more important cases I avoided it altogether by quickly taking the reading with the aid of a screen, and then retiring for some minutes to the other side of the room before taking a second reading.

Experiment with gas flame and a solution of alum.—The light of a luminous gas flame at a distance of a foot, after passing through a saturated solution of alum 41 mm. thick, was allowed to act on the blackened side of the disc, and forty readings were taken at intervals of about twenty seconds. A repulsion from the light was produced; below is given the deviation indicated by the mean of each successive set of ten readings.

0°·6 4°·01 3°·01 4°·1.

The alum solution was now removed, when the disc began to move rapidly toward the light, and after twenty readings, had reached a final deviation of 28°·7 toward the light. Here it remained stationary with small fluctuations. Being convinced that the deviation of 28°·7 was due solely to the heating of the glass by the naked gas-flame, causing thus a current to set toward it, and drawing the disc in that direction after the manner of a weather-cock, I moistened the side of the glass next to the gas flame with water at the temperature of the room, by the aid of a small camels' hair brush. For a second or two, no effect was produced; then a large repulsion ensued rather forcibly, the disc being driven away from the light, a deflection of as much as 180° being obtained, which tended of course to confirm the idea I entertained.

While making the observations just mentioned, I was seated near the apparatus: they were now repeated, at intervals of two minutes, the alum solution being employed, and the observer removing each time to a considerable distance from the apparatus. Below are the results of three experiments, consisting each of only two determinations of the zero point, and two of the deflection: 16°, 15°·4, 15°·8 away from light.

These and other equally constant results established beyond a doubt the fact that repulsion takes places when the radiations are such as not sensibly to heat the walls of the flask, and it is seen that with these conditions, the disc under the full atmospheric pressure *imitates the behavior of one suspended in a vacuum.*

I conceive the cause of these phenomena to be as follows: the radiations falling on the blackened disc heat it, and generate thus an ascending current of air, which sweeps upward along the surface of the disc, *gathering volume* as it travels from the lower to the upper edge, and tending thus to drive the disc away from the light. The cross section of the ascending current of heated air would then, roughly speaking, assume a shape like a V. To test this idea, I arranged the disc so that its upper edge should be bent away from the light, like an A, so as to give room to the ascending current of air; now, instead of hanging with its walls vertical, they were deflected as much as 15°. This deflection was so small as not materially to diminish the projection of the surface exposed to the light, but it was found practically to destroy the repulsion. Four experiments were made, each consisting of four readings of the zero point, and as many of the position of the disc after exposure, the observer removing each time to a distance from the apparatus; the results are given below.

Toward the light.	Away from light.
0°·2	2°·4, 0°·1, 1°·1.

This gives as the mean result a repulsion of 0°·8, and shows that the phenomenon differs essentially from that involved in a Crookes' radiometer.

With this same apparatus, the disc being still bent out of its vertical position, I now repeated the fundamental experiment of exposing the apparatus to the action of a naked gas flame under atmospheric pressure; the results of these trials are given below.

(1.) The disc remained stationary a moment, and then moved toward the light.

(2.) Same result.

(3.) Moved a few degrees away from the light, afterward 40° or 50° toward it.

(4.) 8° away from light, then a large number of degrees toward it.

(5.) Small deviation toward light, small deviation away from it, large deviation toward it.

(6.) Disc stationary, 5° away, 50° or 60° toward light.

(7.) 5° or 6° toward light, stationary, large deviation toward light.

The blackened disc was now arranged so as to hang vertically, and the experiment repeated, all the other conditions remaining unaltered.

(1.) Repelled 20°; then began to move slowly toward flame; on extinguishing the latter, a large sudden motion in same direction.

(2.) Repulsion of 40° or 50°; return to zero point; remained nearly stationary at zero point; sudden and large deflection toward flame, when it was extinguished.

(3.) Same as last.

(4.) Repulsion of about 5°, attraction 60°.

These experiments show that, as a general thing, the first effect is repulsion, the second attraction. They are, I think, sufficiently explained by assuming the existence of a vertical current, on the heated surface of the disc, and a horizontal current directed toward the heated side of the flask; these act antagonistically, and when the disc is vertical, often balance each other more or less perfectly for quite an interval. On extinguishing the flame, the vertical current is greatly weakened, while the horizontal one is not much affected, hence the violent deflection toward the heated side of the flask.

New York, June 27th, 1876.

ART. XLIV.—*Experiments on the Sympathetic Resonance of Tuning Forks;* by ROBERT SPICE.

IT is well known that a pair of forks having a vibration number of 256, (Kœnig's Ut^3 forks) show the phenomenon of sympathetic resonance at distances apart varying from three to six feet. Beyond six feet, special and delicate means have to be employed to exhibit their resonance.

It is also well known that a pair of forks having a vibration number of 512, (Ut^4 forks) exhibit the phenomenon with similar intensity at far greater distances. The accepted solution of this difference of deportment is, that as in the latter case double the number of impulses are delivered in a second, consequently double the energy is conveyed to the distant fork.

If this explanation be sufficient, the following result should follow: Forces radiating from a center obey the law of inverse squares; hence, if the amount of motion (or force?) received by an Ut^3 fork at a distance of six feet from its excited fellow be represented by n; then (assuming an Ut^4 fork to have double the energy of an Ut^3 fork,) clearly, the amount of motion received by an Ut^4 fork at a distance of twelve feet from its excited fellow, should be represented by $\frac{n}{2}$. But so far is this from being the case, that the intensity instead of being one-half (as calculated) is more than double. In fact, at twenty feet the

intensity of resonance of Ut⁴ forks is undoubtedly greater than the intensity of Ut³ forks at six feet.

A pair of forks were cast in a kind of bell-metal, and tuned to Ut³. On Kœnig's boxes the resonance was quite obvious at twenty feet, and at forty feet the responding fork drove a cork ball 8^{mm} diameter a distance of 10^{mm}! This result was greater than that obtained with the steel Ut⁴ forks of Kœnig. In view of these facts, it seemed to me that a different explanation was required to clear up the difficulty: and, after a careful experimental examination of the question, I offer the following hypothesis:

The intensity of sympathetic resonance of forks on their cases increases with the angular deviation or motion of the prongs.

The question of number of vibrations per second has its proper value, but this value is small compared with the element above stated.

I proceed to explain this hypothesis. Suppose that we wish to set a pendulum in motion, but are required to fulfill the two following conditions: First. We are obliged to hold the cord of the pendulum (point of suspension) in our hand, and this hand is also to be the motive power, to start and keep the pendulum in motion. Second. We are only to be allowed a lateral movement of the hand of one inch each way, making in all two inches.

Now the amount of motion or amplitude of a pendulum is estimated by the angle the cord or rod makes with the vertical; and clearly, if the point of suspension moves laterally, it thereby creates an angle. If, further, the point of suspension has a reciprocal motion in accord with the possible time of the pendulum, then, by the principle of the summation of impulses, the motion of the entire pendulum will be gradually augmented up to a limit determined by well-known mechanical theorems. But if amplitude is expressed by angular magnitude, then, if the initial angle be increased, the total motion must be acquired in less time and be greater. From which it follows that, retaining the conditions above stated, if we operated on a pendulum ten inches long, we should set it in its maximum motion in less time and with less expenditure of force than if we operated on a pendulum fifty inches long. Experience confirms this.

A fork vibrates after the manner of a pendulum, and may be looked upon as an inverted pendulum; but whereas, the *length* of a pendulum determines its vibrating period, the *length* and *thickness* together determine the period of a fork. Again: the period of a fork varies *directly* as the *thickness*, but inversely as the *square of the length;* hence a small alteration of length will make a large difference in its period; or, conversely, a

large alteration of period does not imply a large difference in length.

From measurements made with an electro-chemical registering apparatus, which I designed for this and similar investigations, I find that when a fork of the usual dimensions (between Ut^3 and Ut^4) is in vibration, its stem or handle alternately rises and falls in accord with the period of the fork, through a distance of about $\frac{1}{50}$ inch. When a fork on its case is influenced by a distant fork, the case gives the stem this up and down motion, which is conveyed to the prongs and sets them in vibration after the manner of the hand starting a pendulum as specified above.

This motion of $\frac{1}{50}$ inch may be looked upon as a constant, and corresponds to the two-inch motion of the hand in the illustration. If we decrease the length of the fork without altering the constant, we thereby allow of a greater initial angle; the result of which we have already noted—it is the same as shortening the pendulum cord. This much understood, we are in a position to explain the deportment of the bell-metal forks cited. The velocity of sound in bell-metal is much less than in steel, hence, retaining similar thicknesses in both cases, an Ut^3 fork in bell-metal would be shorter than an Ut^3 fork in steel; the ratio of the length of the steel to that of the bell-metal ranging as 90 : 75. Therefore, though we retain the vibration-number, we gain advantage from the shortness of the fork, and hence from the increase of angular motion of the prongs.

It was suggested to me that possibly bell-metal had the property of accepting motion more readily than steel. To test this point I made a pair of Ut^3 steel forks, shorter than Kœnig's, and of course thinner, in order to retain the vibration-number. These forks behaved just like the bell-metal forks. Further, I made a pair of Ut^4 forks as long as Kœnig's Ut^3 forks, and of course thicker. These behaved like Kœnig's Ut^3 forks. Finally, taking a Kœnig Ut^3 fork on its case, and one of the short Ut^3 forks also on its case; on placing them twenty feet apart, it was found that, on exciting Kœnig's fork, my short fork responded well, whereas on exciting the short fork Kœnig's did not respond at all.

230 Bridge st., Brooklyn, July, 1876.

Art. XLV.—*Types of Orographic Structure;* by Major J. W. Powell.

[The following pages on "Types of Orographic Structure," are cited from Major Powell's Report on the "Geology of the Uinta Mountains." They are preceded in the volume by a brief topographical account of the region between the Sierra Nevada and the Front Range of the Rocky Mountains, and having for its northern boundary, as at present understood, the North Platte and its proper upper continuation, the Sweetwater River. This area is divided into three provinces, namely—passing from east to west,—the Park Province, the Plateau Province and the Basin Province. The first is described as including the great parks of Southern Wyoming, Colorado and Northern New Mexico, and comprises many ranges of mountains which are "characterized by a great development of metamorphic crystalline schists, mostly Archæan in age, with patches and structural basins of marine and lacustrine sediments of later time, and a complicated series of volcanic formations.

The Plateau Province is that directly drained by the Colorado and its tributaries, through which the streams generally run, not in wide valleys, but in cañons; the vast area is strictly a plateau region embracing many table-shaped elevations bounded by cañon and cliff escarpments, and differing in its succession of sedimentary strata from others in North America, and also in its displacements or uplifts; moreover, Cenozoic and Mesozoic rocks prevail, though some of the important plateaus are of Carboniferous beds, and in places the subjacent rocks even down to the Archæan are exposed to view in consequence of erosion.

The Basin Range system includes the Great Salt Lake region, and other valleys and ridges extending through Western Utah, Nevada, Southeastern California and perhaps across the Colorado in Western Arizona; and embraces Paleozoic beds as well as metamorphic schists, along with eruptive beds, some of which are the principal component parts of the ranges.]

It seems convenient to give a general account of the types of orographic structure in the Colorado region before characterizing each province by its special type.

In this discussion I wish to use certain terms with a restricted or relative meaning; i. e., in treating of anticlinal and synclinal flexures I shall speak of those portions of the sedimentary beds which are adjacent to the anticlinal axes as having been upheaved, and those portions near their synclinal axes as having subsided. Again, in blocks which are bounded by faults and tilted, I shall speak of such portions as are at a higher level as having been uplifted, and portions occupying a lower level as thrown. In such cases I do not wish to commit myself to any

theory of upheaval or collapse in the change of the relation of the several parts of these beds to the center of the earth.

In treating of the structure of the mountains under consideration it is necessary to distinguish two great classes, viz: those composed of sedimentary strata, altered or unaltered, and those composed of extravasated material.

Mountains composed of Sedimentary Strata.

I. *Appalachian Structure.*

The structure of the Appalachian Mountains, with closely appressed folds and axial planes tipped back from the sea, the modifications of these folds by faults, and the primary and concomitant forms of the mountains, have been clearly explained by the Messrs. Rogers and later writers, and have formed the basis of many discussions concerning geological dynamics. This Appalachian structure needs no further mention here, as it is a type of structure which so far has not been found in the region described above, and should it be found hereafter it will simply be an exceptional type to those known to prevail.

II. *Simple Anticlinal Structure.*

Mountains or short ranges carved from simple anticlinals are sometimes found, though this type of structure is not a prevailing one. Usually in such a case the great mountain mass lies in the central zone of the uplift. The fold is, of course, always found truncated by erosion, and the mountains represent but the difference between the amount of upheaval and the amount of such erosion. When not complicated by other types of structure the strata dip on all sides from the center of upheaval, gently or more abruptly, but the sides of the folds are never closely appressed. Such mountains in primary form are gently rounded in general outline, modified by the erosion of the streams running down their sides. Sometimes such mountains are severed by rivers running longitudinally, transversely or obliquely through them; the rivers themselves having their sources in regions far away and passing through the mountains in their courses to the sea. In Northeastern Colorado a short distance above the junction of the Snake River with the Yampa, stands Junction Mountain, which serves as a fine illustration of this type of structure. The mountain is divided into two unequal parts by a cañon, through which the Yampa River runs. The axis of the mountain has a north and south direction.

Figure 1 is a section through this mountain, in a north and south direction, along the axis of upheaval. Figure 2 is a section through it in a transverse direction.

CONCOMITANT FORMS.

1. *Monoclinal Ridges on the Flanks.*—Under conditions which are so well known as to need no further explanation here, monoclinal ridges or hogbacks are formed on the flanks of such up-

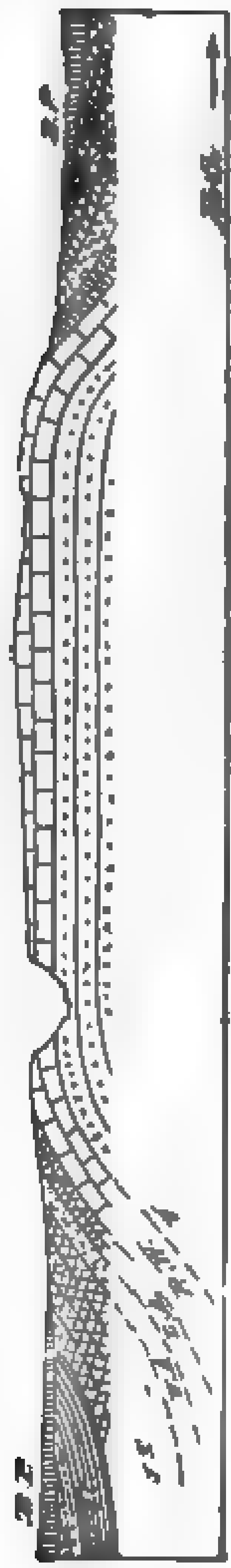


FIG. 1.—Section through Junction Mountain, north and south.

FIG. 2.—Section through Junction Mountain, east and west.

B. P., Brown's Park; S. C., Sulphur Creek; J. T., Jura Trias; U. A., Upper Aubrey; L. A., Lower Aubrey; R. W., Red Wall; U., Uinta.

heavals, and sometimes such monoclinal ridges are of such magnitude as to be dignified with the name of mountains. Where two or more series of indurated, inclined beds are separated by extensive series of softer material, two or more monoclinal ridges may be formed.

2. *Monoclinal Ridges only.*—Sometimes we find that an anticlinal upheaval has been eroded in *intaglio*, so that there is no great central mountain mass, but the axis of upheaval is the site of a valley or low plain, but the monoclinal ridges on the flanks remain.

3. *Inclined Plateaus.*—Where the anticlinal upheaval has a great amplitude, as compared with the vertical uplift, the beds incline but slightly. Under such conditions inclined plateaus or mesas are found instead of monoclinal ridges, usually having steep escarpments facing the axis of the flexure.

III. *Uinta Structure.*

In the Uinta Mountains we have a great range carved from an anticlinal upheaval, the axis of which has an easterly and westerly trend, and is more than one hundred and fifty miles in length. It terminates abruptly against the Wasatch Mountains on the west and is cut off by the short, abrupt anticlinal of Junction Mountain on the east, the latter having its axis in a north and south direction. There are several important facts observed in the study of this great flexure. Its axis has been lifted above the level of the sea about thirty thousand feet, and above the level of the adjacent country about twenty-five thousand feet. From flank to flank the flexure is about fifty miles, but varies much in width. We find on either flank, many miles from the axis, a line of maximum flexure, which line presents a subparallelism with the meandering axis. These lines have the effect of two monoclinal flexures in opposite directions, separated by the broad table, diversified by elevated valleys and peaks of which the great mass of the Uinta Mountains is composed. But the portion between these monoclinal flexures or lines of greatest flexure is itself gently flexed. In many places that which I have called the line of greatest flexure is indeed a fault, in one place on the north side of the Uinta Mountains having a throw of twenty thousand feet. On the south side the line of greatest flexure is very irregular, being complicated in some places by faults having uplifts opposed to the downthrow of the flexure. On either side the great displacement is partly by faulting, partly by flexing, and either flank is a zone of diverse displacement where the strata are faulted, flexed, twisted and contorted in many ways.

The character of these displacements in the Uinta Mountains is illustrated in Plates, 1, 2 and 3 of the Atlas, and in a subsequent chapter the subject will be more fully discussed.

The simplest topographic forms, produced by such displacements under conditions of erosion in general outline, are plateaus with gently rounded summits and abrupt shoulders on the flanks; but such general outline is often modified by the

corrasion due to antecedent or superimposed drainage; that is, by the corrasion of streams that head in remote regions and pass through these uplifts either longitudinally, transversely or obliquely, as in the case of Simple Anticlinals.*

There are other modifications which sometimes greatly obscure the general topographic outline due to consequent drainage, i. e., the local drainage which is due to the upheaval itself and which produces interesting

Concomitant Forms.

1. *Subsidiary Plateaus.*—Sometimes the streams which head near the axis of such an upheaval, as they meander to the flanks, excavate valleys and divide the great block, which is a plateau in general outline, into minor plateaus which are separated by intervening but elevated valleys. This is especially the case where the streams in their upper courses follow for some distance the strike of the beds before turning to cross the more or less abrupt lines of maximum flexure. Sometimes these streams run in deep gorges; in such cases the plateaus are bounded by cañons.

2. *Projecting Ridges.*—When these consequent streams starting near the axis of upheaval take a somewhat direct course across the strike, the general plateau is cut into a series of sharp, abrupt ridges having a trend at right angles to the strike or general axis of upheaval. Thus the points of the ridges face the plain below and are separated by deep gulches and cañons, and the observer on the plain below sees before him what appears to be a line of peaks separated by intervening gulches and valleys, and is apt to misunderstand the topographic character of the great mass which is before him.

3. *Axial Peaks.*—At some stages in the progress of erosion the channels of consequent drainage inosculate, and about their heads gorges are formed, with towering amphitheaters. In such cases an irregular line of crags and peaks will be found along the axis of upheaval. These I call axial peaks.

4. *Flanking Peaks.*—Sometimes we find a very hard bed or group of beds underlaid by more friable strata on a flank of the upheaval, which harder beds have been carried away by erosion from those portions of the upheaved mass nearer the axis. In such cases each projecting ridge is crowned with a true peak. I call these flanking peaks.

5. *Interrupted Monoclinal Ridges.*—On the flanks of these upheavals, but farther from the axis than the flanking peaks, monoclinal ridges are often found sometimes broken by gaps

* For an explanation of what is meant by antecedent and superimposed drainage, the reader is referred to the Report on the Exploration of the Colorado River and its Tributaries, page 160, *et seq.*

which are the channels of intermittent or permanent streams, and these ridges are very irregular and often interrupted. Where the downthrow is by simple flexure, a complete series is formed. Where it is partly by flexing and partly by faulting, some of the monoclinal ridges disappear. Where the faulting is on the side of the zone of maximum flexure nearest to the axis, the ridges of the upper beds appear; but where the faulting is on the side of the zone of maximum flexure farthest from the axis, the ridges of the lower beds appear; and where the displacement is chiefly or entirely by faulting, there are no monoclinal ridges.

IV.—*Kaibab Structure.*

In the region under discussion we often find the sedimentary beds broken into blocks by faults or their homologues, monoclinal flexures, and these blocks have been gently tilted in broad masses. I have discussed this subject somewhat at length in my Report on the Exploration of the Colorado River of the West and its Tributaries, published in 1875; and in fig. 3 I reproduce a section and bird's eye view of the plateaus north of the Grand Cañon, which was used in that volume. An examination of this will fully reveal the characteristics of what I have called the Kaibab structure. The grand topographic features which result from this structure are plateaus with broken edges where they are bounded by faults, flexed edges where they are bounded by monoclinal flexures, and with escarpments where they are bounded by cañons or lines of cliffs.

Concomitant Forms.

1. *Cliffs of Displacement.*—When a plateau is bounded on one side by a fault, the edge of the plateau is an escarpment often so abrupt as to present a more or less irregular line of cliffs.

2. *Slopes of Displacement.*—When the displacement is a flexure rather than a fold, the edge of the plateau is a broken slope. I have discussed these cliffs and slopes of displacement somewhat at length in the volume already quoted several times, page 182 *et seq.*

3. *Monoclinal Ridges on the Flanks.*—On the flanks of these monoclinal flexures, under proper conditions which have already been described, monoclinal ridges are formed.

4. *Monoclinal Ridges with Plateau carried away.*—As in simple anticlinal upheavals the central mass may be entirely carried away leaving but monoclinal ridges, in like manner in the Kaibab structure the principal plateau mass may be carried away leaving only the monoclinal ridges. This I have also discussed in the volume already quoted.

5. *Projecting Ridges.*—It is seldom, perhaps never, the case that the strata of one of these plateaus are left by the general

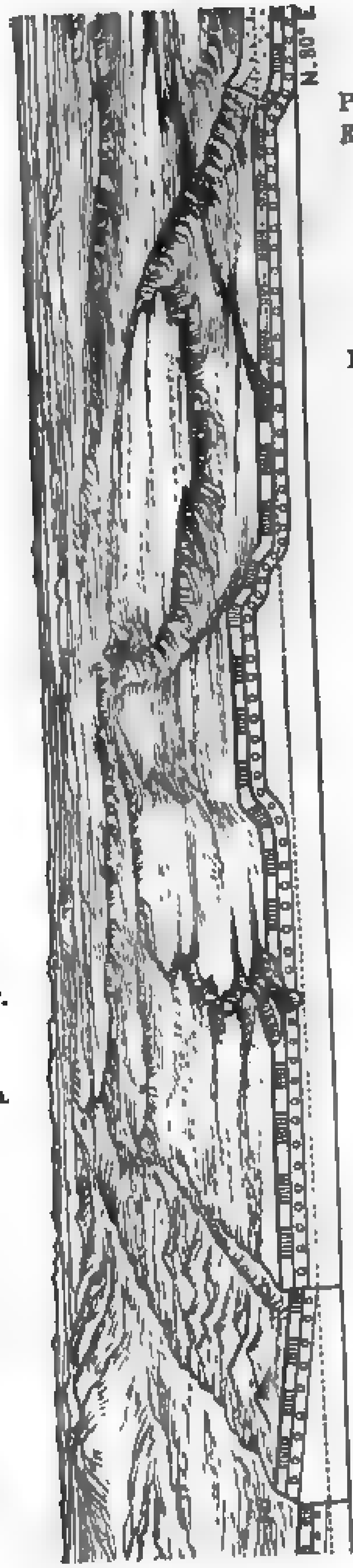


FIG. 3.—Section from west to east across the plateaus north of the Grand C with bird's-eye view of terraces and plateaus above. Horizontal scale, 16 mi the inch; vertical scale, 4 miles to the inch.

displacement in a horizontal position; but every block is tilted more or less, and often a valley appears at the foot of the slope, and the streams which head on the opposite brink of the plateau have excavated valleys, leaving intervening ridges which project into the valley, having an effect somewhat like that described as one of the concomitant forms of the Uinta structure.

6. *Cliffs of Erosion.*—An inclined plateau may be bounded on the upheaved side by an escarpment of erosion, and such an escarpment is gradually carried back by an undermining process from the line of greatest upheaval. The drainage of such a plateau is usually from the brink of this escarpment toward the valley on the opposite side; yet a minor drainage is found which carves out deep gulches, and the cliffs of erosion have deep reëntrant and sharp salient angles.

7. *Buttes.*—Sometimes the gulches which form the deep, reëntrant angles of a line of cliffs have lateral gulches, which by continued erosion coalesce, and the salient angles are gradually cut off from the escarpment, which is ever retreating. In this manner buttes are formed as outliers of cliffs.

8. *Cameo Mountains.*—Wherever considerable areas of horizontal or nearly horizontal strata are found sufficiently elevated above the base level of erosion, and such areas are drained by two or more subparallel water-courses, the lateral drainage of these water-courses will gradually inosculate in their upper ramifications, and, carving out deep channels, will leave behind mountains of horizontal strata. Such mountains are often of great beauty. This is especially the case where the beds are of different texture and color, when the mountains will be terraced and buttressed in beautiful regularity, and banded with the colors which are characteristic of the several beds of which they are composed.

A few miles north of the Uinta Mountains, on the west side of the Green River, a group of such mountains is found, to which I have given the name Cameo Mountains, and I call this the Cameo structure.

V. *Basin Range Structure.*

When the blocks into which a district of country has been broken by faults are greatly tilted so that the strata dip at high angles, the uplifted edges of such blocks often form long mountain ridges. Such ridges have the general appearance of the monoclinal ridges already described as concomitants of other types of structure: but in this case the ridges constitute the chief mountain masses themselves, and form another general structural type. The monoclinal ridges are due to the erosion of upheaved strata; these ridges are due to displacement; they may also be eroded, but in so far as erosion has progressed the

ridge-like structure is obscured. Many of the ridge-like moun tains of the Basin Province have this structure. Such a ridg is composed of monoclinal strata, the one side presenting a bol escarped front, the other a more gently sloped back conformin

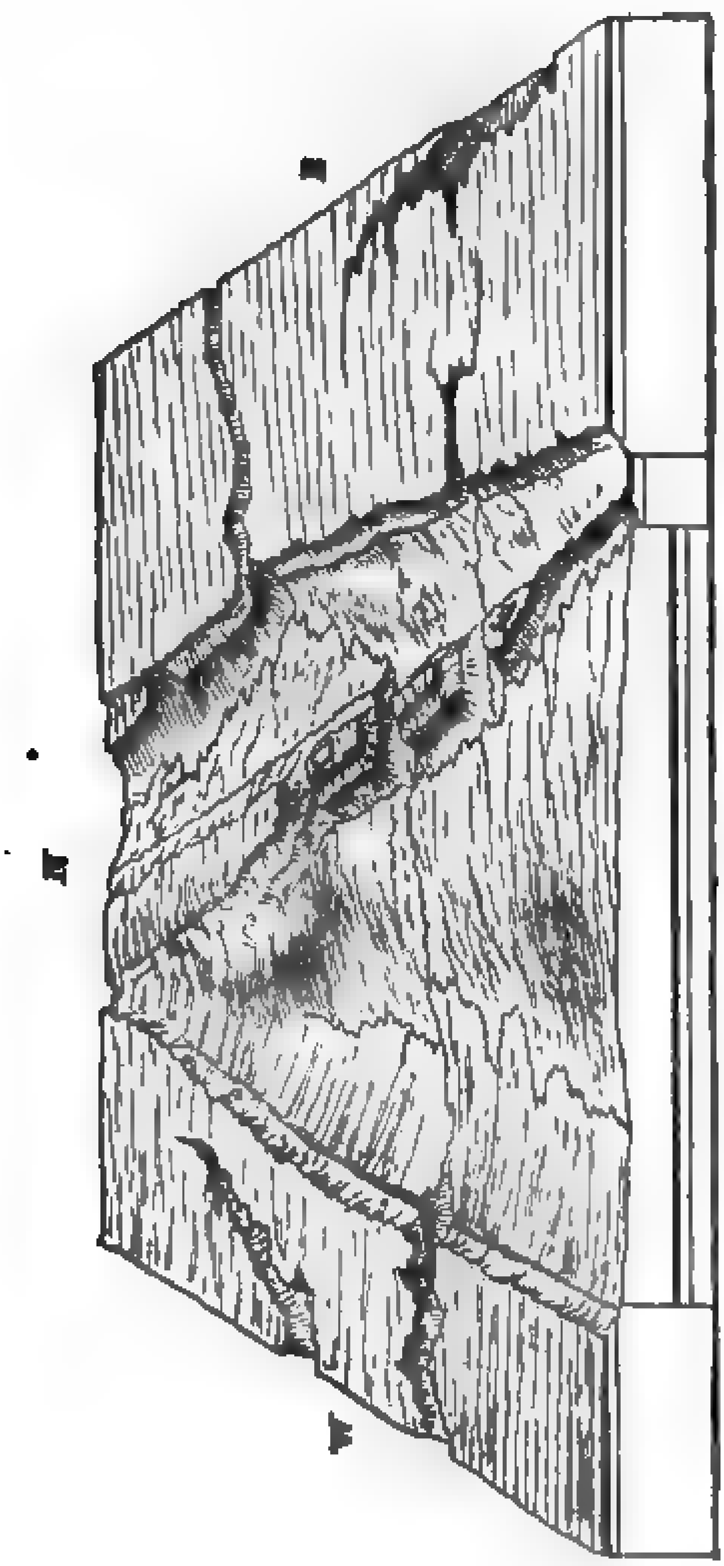


Fig. 4.—Bird's-eye view of a portion of the Musinia Zone of Diverse Displacement. The area represented is six miles square. The base line shows the sea-level. The tract is drained by Salina Creek, which unites its branches in the center and flows through the cañon on the left.

to a greater or less degree with the dip. Sometimes the ridge themselves are faulted longitudinally, transversely or obliquel and the faults may be slight or of great magnitude; but th more common structure is a simple ridge with slight transvers or oblique faults.

CONCOMITANT FORMS.

1. *Monoclinal Ridges on the Back.*—On the backs of these asin ranges monoclinal ridges have been observed.

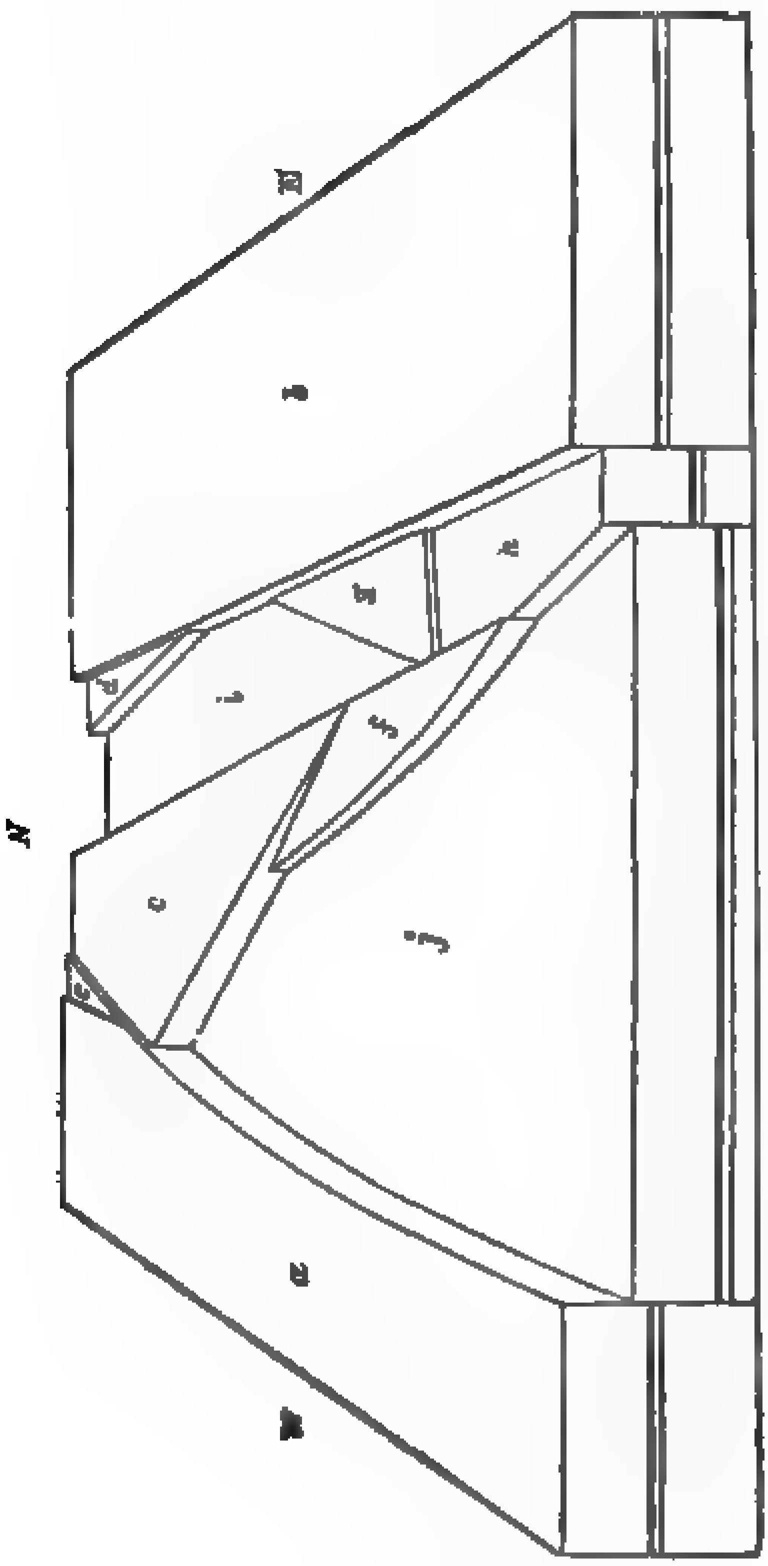


FIG. 5.—Deduced from Fig. 4. A restoration of the displaced rocks as they would appear had there been displacement but no degradation.

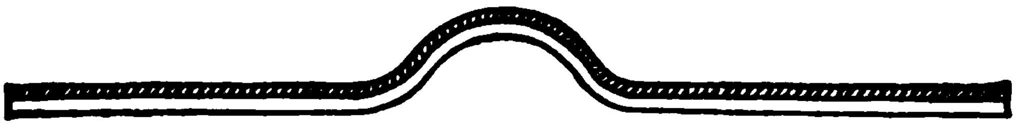
VI.—*Zones of Diverse Displacement.*

In this region many zones or irregular areas of country are ound to be divided into small blocks by faults and flexures nning in diverse directions, and these may be horizontal or e tipped at high or low angles, or even be overturned. The tal effect of this diverse displacement may be to uplift the

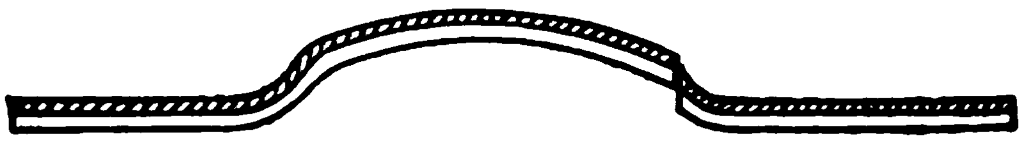
area above, or depress it below, the adjacent country, or not to change its relative altitude. These features are exhibited on a small scale within a limited area, usually so elongated as to be termed a zone.

During the past season Mr. G. K. Gilbert has studied an area where this diverse displacement is by faulting, and the faults are of no great magnitude, and the blocks into which the area has been severed are either not tilted or but slightly so. This presents the simplest illustration of this type that has yet been discovered. It is simply the Kaibab structure on a very small scale. Fig. 4 is a bird's eye view of the blocks mentioned. In

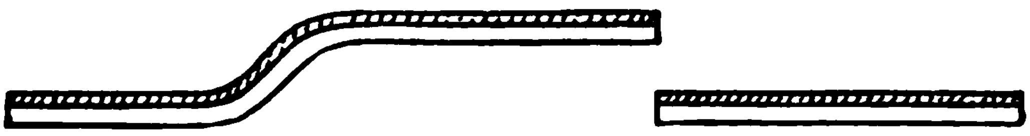
FIG. 6.—Types of Displacement.



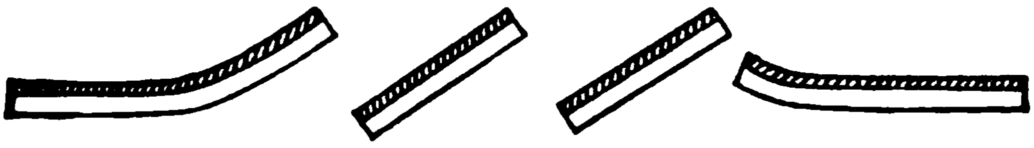
A.—Simple Anticlinal displacement.



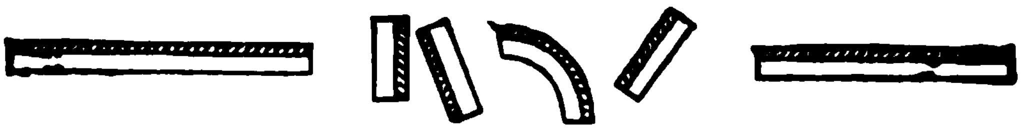
B.—Uinta displacement.



C.—Kaibab displacement.



D.—Basin Range displacement.



E.—Zone of Diverse displacement.

the section, in the foreground, the heavy line represents the summit of the highest Cretaceous group. Fig. 5 is a diagram of the same region showing the blocks into which it is severed, and the same restored to the condition they would have, had there been no denudation.

On the south side of the Uinta Mountains, and east of the Green River, another comparatively simple area has been studied by myself. This zone of diverse displacement is on the flank of the great Uinta upheaval. These displacements are chiefly by flexures rather than by faults, and the blocks are more tilted and contorted than in the last.

In Atlas, plate No. 4, we have a stereogram representing these displacements, and in a subsequent chapter the subject is more fully discussed.

Many other areas far more complex than these have been discovered, where a zone has been broken into blocks, and these blocks tipped and contorted in diverse ways and directions, like the blocks of ice crowded in an eddy of a northern river at the time of its spring flood. The topographic features found in such areas are zones of irregular hills.

Figure 6 is a diagram illustrating the general types of displacement heretofore discussed. A represents a Simple Anticlinal displacement; B, a Uinta displacement; C, a Kaibab displacement; D, a Basin Range displacement; and E, a Zone of Diverse displacement.

Mountains composed in whole or in part of Extravasated Material.

We are not able in the present state of our knowledge to draw legitimate conclusions concerning the relation of the eruptive rocks, so widely distributed through all three of these geological provinces, but the following types of structure have been observed.

VII.—*Table Mountain Structure.*

We often find beds of sedimentary strata preserved from erosion by a capping of lava. Such are usually called table mountains; the underlying strata may be horizontal or inclined. Earlier stages of this structure are seen in *mesas* or low tables, and sometimes in valleys or gulches which have been filled with extravasated material, and erosion has proceeded to a limited extent on either side of these harder masses, carrying away the softer sedimentary material, and leaving the harder volcanic rocks in the midst of the valley; and this may have an elevation less or greater than that of the adjacent country beyond the rim of the valley.

A fine example of a table mountain is found in Pilot Butte, in Wyoming Territory.

VIII.—*Uinkaret Structure.*

Simple sheets of lava may be poured into a valley or on a plain, and serve as a protection to the sedimentary beds which are immediately underlying them, and as the erosion of the adjacent country not thus protected progresses, new vents may be formed along the edges of such sheets and at a lower level. Still erosion progresses, and still new floods of lava are poured out, and still at lower levels, until a mountain is left behind with its central mass composed of sedimentary material, but covered on the summit and flanks with irregular and overlap-

ping patches of lava. Thus lava bed is imbricated on lava bed, but unlike the tiles of a roof, the upper edge of the lower sheet is placed on the lower edge of the upper. This structure is well represented in the Uinkaret Mountains in Northern Arizona, and has been more fully discussed by me elsewhere. (*Vide* The Exploration of the Colorado River, &c., page 199 *et seq.*)

IX.—*Tu-Shar Structure.*

When a plain or valley which receives extravasated material from below remains at a base level of erosion during the period of successive eruptions, flood of lava is piled on flood of lava until a vast mass of material is accumulated from which the rains and streams carve mountains. The several beds of which such a mountain mass is composed are exceedingly irregular, from three causes: first, each bed as poured out was an irregular mass, due to its degree of fluidity and the character of the ground on which it was poured; second, each bed was more or less modified by erosion, which occurred after it was poured out, and before it was covered by a subsequent flood; and, third, the general mass has been eroded to a greater or less extent in producing the present forms.

The volcanic activity being in a region where movements of displacement are in progress, it is often the case that the structure of this class of mountains is greatly modified by such displacements. Mountains composed of such irregular beds of lava are of frequent occurrence in the region under discussion. A fine example is seen in the vicinity of the town of Beaver, Utah Territory, in what are known as the Tu-shar Mountains.

X.— *Volcanic Structure.*

When many eruptions come successively from the same vent, and each is a comparatively small amount, cones are built. Cones of such simple structure are of frequent occurrence in the region under discussion. Great complex cones such as are found in other parts of the world do not occur, but a few double and one triple cone have been observed. The great majority of the cones observed are built of cinders on broad sheets of lava, and are in fact concomitant forms of lava mesas. Such cones are comparatively ephemeral, as the scoria and ashes of which they are composed yield readily to atmospheric degradation. Where such a cone exists, still having a well defined crater, its condition testifies to the lateness of its origin, and all the facts relating to the sheet of lava on which it rests fully corroborate the conclusion. From such evidence we are able to infer the recency of much of the volcanic activity in the three provinces. If the human history of America could be carried back to as early a date as it has been in Asia, it cannot be doubted that the earlier chapters of that history would be replete with the accounts of volcanic fires.

XI.—*Henry Mountain Structure.*

Sometimes we find the sedimentary strata displaced by a quaquaversal upheaval and the same fractured, and through these fractures floods of lava have poured, and these may lie in patches about the flanks of the mountains, or stand in dikes where the walls of the crevice have been swept away by denudation. In the Henry Mountains we have a fine illustration of this type of structure. These mountains have been studied by Mr. Gilbert during the past season, and in his preliminary report he says: "The eruptions of the Henry Mountains are of a character entirely novel to me, and they were studied with an interest stimulated by surprise. A description of a single one, though it will not stand for all, will serve to illustrate the type.

Mount Ellsworth is round, and its base is six or eight miles broad. The strata of the plain about it are horizontal on every side. Near the mountain the level strata become slightly inclined, rising from all sides toward the mountain. At its base the dip steadily increases until on the steep flanks it reaches a maximum of forty-five degrees. Then it begins to diminish, and the strata arch over the crest in a complete dome. But the top of the dome has cracked open, and tapering fissures have run out to the flanks, and they have been filled with molten rock, which has congealed and formed dikes. Moreover, the curving strata of sandstone and shale have in places cleaved apart and admitted sheets of lava between them. So the mountain is a dome or bubble of sedimentary rocks with an eruptive core, with a system of radial dikes, and with a system of dikes interleaved with the strata. It is a mountain of uplifted strata, distended and permeated by eruptive rock."

* * * * * *

In the foregoing characterization of certain types of structure found in these regions, I have not attempted to adopt a system of exact classification, which should be both inclusive and exclusive as the types do not admit of such classification. No "hard and fast lines" can be drawn. I have simply attempted to indicate the important types with their primary and concomitant forms.

It is manifest that the structure of a sedimentary mountain will depend primarily upon two elements—the type of the displacement and the character and extent of erosion. The erosion may be antecedent or superimposed, or it may be consequent, or these methods may be combined, and the erosion may be modified by dip, texture, and other characteristics of the beds producing concomitant forms.

For convenience, I subjoin the following synopsis of the types of mountain structure recognized in the foregoing discussion.

I. MOUNTAINS COMPOSED OF SEDIMENTARY STRATA, ALTERED OR UNALTERED.

I.—*Appalachian Structure.*

(Not found in the three provinces.)

II.—*Simple Anticlinal Structure.*

Primary topographic form: Plateau with rounded vertical outline.

Concomitant forms: 1. Monoclinal Ridges on the Flanks. 2. Monoclinal Ridges only. 3. Inclined Plateaus.

III.—*Uinta Structure.*

Primary topographic form: Plateau with rounded summit and abrupt shoulders on the flank.

Concomitant forms: 1. Subsidiary Plateaus. 2. Projecting Ridges. 3. Axial Peaks. 4. Flanking Peaks. 5. Interrupted Monoclinal Ridges.

IV.—*Kaibab Structure.*

Primary topographic form: Plateau with angular outlines.

Concomitant forms: 1. Cliffs of Displacement. 2. Slopes of Displacement. 3. Interrupted Monoclinal Ridges on the Flanks. 4. Monoclinal Ridges with Plateau carried away. 5. Projecting Ridges. 6. Cliffs of Erosion. 7. Buttes. 8. Cameo Mountains.

V.—*Basin Range Structure.*

Primary topographic form: Monoclinal ridges of displacement.

Concomitant forms: 1. Monoclinal ridges on the back.

VI.—*Zones of Diverse Displacement.*

Topographic form: Irregular hills.

II. MOUNTAINS COMPOSED IN WHOLE OR IN PART OF EXTRAVASATED MATERIAL.

VII.—*Table Mountain Structure.*
VIII.—*Uinkaret Structure.*
IX.—*Tu-Shar Structure.*
X.—*Volcanic Structure.*
XI.—*Henry Mountain Structure.*

ART. XLVI.—*On the Ethers of Uric Acid. Contributions from the Chemical Laboratory of Harvard College*; by H. B. HILL,* Assistant Professor of Chemistry.

ALTHOUGH the constitution of many of the derivatives of uric acid may be said to be fairly established, the structure of uric acid itself is still a matter of conjecture. The formulæ given by Bäyer,† Kolbe,‡ Strecker,§ Erlenmeyer,‖ Mulder,¶ Hüfner,** Gibbs,†† Medicus,‡‡ Drechsel,§§ and Mallet;‖‖ dif-

* In great part from the yet unpublished Proceedings of the Am. Acad., p. 26.
† Ann. Chem. u. Pharm., cxxvii, 235.
‡ Journ. für prakt. Chem. II, i, 134. Berichte Deutsch. Chem. Gesellsch., iii, 183.
§ Zeitschr. für Chem., 1868, 363.
‖ Zeitschr. für Chem, 1869, 176. München. Acad. Ber., ii, 276.
¶ Bericht. der Deutsch. Chem. Gesellsch., vi, 1237.
** Journ. für prakt. Chem., II, iii, 23.
†† Am. Journ., II, xlvi, 289.
‡‡ Ann. Chem. u. Pharm., clxxv, 243.
§§ Journ. für prakt. Chem., II, xi, 352.
‖‖ Am. Journ., III, xi, 195 1876.

fering as they do, in points more or less essential, show that the experimental data are as yet insufficient to establish its structure. In this connection the ethers of uric acid seem to have attracted little attention. In 1864, Drygin* prepared the diethyl and triethyl ethers by the action of ethyl iodide upon diplumbic urate. I have been unable to obtain the original paper, but from the summary of it given in the Jahresbericht† for that year, and in Gmelin's‡ Hand-book, it would appear that he submitted them to no very extended examination. I have, therefore, undertaken the study of the ethers of uric acid, with the hope that a careful study of the products of their decomposition may throw additional light upon the structure of uric acid.

A few preliminary experiments convinced me that the compounds in the methyl series could be much more conveniently made than those of the ethyl or benzyl. I therefore began with the methyl ethers, and this paper gives the results I have obtained in the study of the first of these.

Methyluric acid, $C_5H_3(CH_3)N_4O_3$.

Methyluric acid may readily be prepared by the action of methyl iodide upon monoplumbic urate. The metathesis takes place slowly at 110°–130°, rapidly between 160° and 165°. The dry lead salt mixed with methyl iodide in molecular proportions, enough ether being added to keep the mixture fluid, is heated in sealed tubes for eighteen hours at 165°. After the evaporation of the ether, the product of the reaction is boiled with water, and the solution filtered from the unaltered plumbic urate. The lead is then precipitated with hydric sulphide, and the plumbic sulphide filtered off boiling hot. The filtrate deposits, on cooling, methyluric acid in small crystals. These are dissolved in dilute potassic hydrate, the solution boiled for a few minutes, reprecipitated by hydrochloric acid, and recrystallized from boiling water. The yield is about sixty per cent of the amount theoretically required by the lead salt which enters into the reaction. A portion of the uric acid is completely decomposed, and is found as ammonium salt in the mother liquors and the crude product. I attempted to increase the yield by employing anhydrous ether in the place of common ether. Although no ammonium compounds were then formed, a much smaller percentage of the lead salt entered into reaction. Longer heating at a lower temperature did not increase the yield, inasmuch as a larger quantity of dimethyl ether was then formed. The amount of dimethyl ether formed by heating to 165° is small; and as it is much more soluble in

* Russ. Zeitschr. Pharm., iii, 3, 28, 49, 113, 121.
† Jahresbericht, 1864, 629.
‡ Gmelin, Suppl., ii, 1026.

water than the monomethyl ether, it may readily be removed by recrystallization.

Methyluric acid crystallizes in small clear flat prisms, apparently of the trimetric system, the crystals being often pointed at either end. By slow cooling of a dilute solution, these crystals sometimes reach a length of 2–3 mm., but they are usually much smaller. The substance undergoes no visible change when heated to about 300°; at a higher temperature, it melts with complete decomposition, and without perceptible sublimation. It is soluble in boiling water, almost insoluble in cold water or in boiling alcohol; insoluble in ether. Cold concentrated sulphuric acid dissolves it abundantly; upon dilution it crystallizes out, apparently unchanged.

The substance dried at 165° has the formula $C_5H_3(CH_3)N_4O_3$, as the following analyses show:

1. 0·4284 grm. gave 0·1310 grm. H_2O, and 0·6210 grm. CO_2.
2. 0·2748 grm. gave 0·0985 grm. H_2O, and 0·3972 grm. CO_2.
3. 0·1822 grm. gave 50·0 c.c. nitrogen, at 20°·5, and 754·3 mm. press.

Calculated for $C_6H_6N_4O_3$.		Found. 1	2	3
C	39·56	39·53	39·43	
H	3·30	3·39	3·98	
N	30·77			30·98

As the mean of several determinations of solubility, I find that there are required for the solution of one part of methyluric acid 253·6 parts of boiling water, and 4596 parts of water at 20°.

The aqueous solution reddens litmus feebly, and decomposes carbonates readily on heating. A solution in potassic or sodic hydrate is not precipitated by carbonic dioxide. From a concentrated cold solution, stronger acids precipitate it gelatinous, from hot or dilute solutions crystalline.

With bases methyluric acid forms a series of definite salts, some of which have been studied by Mr. O. R. Jackson in this laboratory. The results of this investigation may be found in the Proceedings of the American Academy.* He has analyzed the following salts:

$K_2C_5H(CH_3)N_4O_3 \quad 3\ H_2O$
$KC_5H_2(CH_3)N_4O_3 \quad H_2O$
$Na_2C_5H(CH_3)N_4O_3 \quad 3\ H_2O$
$NaC_5H_2(CH_3)N_4O_3 \quad H_2O$
$BaC_5H(CH_3)N_4O_3 \quad 3\tfrac{1}{2}H_2O$
$Ba(C_5H(CH_3)N_4O_3)_2 \quad 4\ H_2O$
$Ca(C_5H(CH_3)N_4O_3)_2 \quad 3\ H_2O$

These salts show that the monomethyl ether of uric acid is

* Amer. Acad. Proc., xii, 36.

itself a bibasic acid like uric acid; a fact which is certainly remarkable and of obvious theoretical importance.

Action of Hydrochloric Acid.

In 1867, Strecker* showed that uric acid heated with fuming hydrochloric or hydriodic acid to 170° assimilates five molecules of water, giving carbonic dioxide, ammonia, and glycocoll,—

$$C_5H_4N_4O_3+5H_2O=3CO_2+3NH_3+C_2H_5NO_2.$$

The inferences which he drew† from this reaction concerning the structure of uric acid are well known. Emmerling‡ has recently shown that cyanogen gas passed into boiling hydroidic acid is converted into glycocoll, and seeks thus to give Strecker's reaction a new interpretation. In either case, however, it seemed to me of importance to determine the products of the decomposition of methyluric acid under these conditions.

Two tubes, each containing 1·3 grm. methyluric acid, and an excess of hydrochloric acid saturated at 0°, were heated four or five hours at 170°. The gas which escaped on opening the tubes was found to contain no methyl chloride. The excess of acid was driven off on the water bath, and the residue distilled with plumbic hydrate until the distillate was no longer alkaline. The ammoniacal distillate was caught in hydrochloric acid, and evaporated to dryness on the water bath. The residue was treated with a small quantity of absolute alcohol, and the filtered solution again evaporated to dryness. There was then left a white saline residue, which gave with great readiness Hofmann's isocyanide reaction, showing the presence of a monamine. The chloride was converted into the platinum salt, and this was analyzed after recrystallization from hot water.

0·4760 grm. gave on ignition 0·1991 grm. platinum.

	Calculated for $(CH_3NH_3)_2PtCl_6$.	Found.
Pt	41·61	41·82

Methylamine is, therefore, one of the products of the reaction.

From the residue left on distillation, it was easy to isolate glycocoll in the ordinary way. The liquid was filtered from the basic plumbic chloride, the lead removed from the solution by hydric sulphide, and the filtrate evaporated. On standing, glycocoll crystallized out with its characteristic properties. For its identification, it was converted into the copper salt by boiling with freshly precipitated cupric oxide, and precipitation of the blue solution by alcohol. Of this salt,—

* Ann. Chem. u. Pharm., cxlvi, 142; Zeitschr. für Chem., 1868, 215.
† Zeitschr. für Chem., 1868, 363.
‡ Berichte Deutsch. Chem. Gesellsch., vi, 1351.

0·4400 grm. lost at 130° 0·0388 grm.

	Calculated for $(C_2H_4NO_2)_2Cu . H_2O$	Found.
H_2O	7·85	7·68

A determination of copper in the dry salt gave,—

0·4068 grm. left on ignition 0·1523 grm. CuO.

	Calculated for $(C_2H_4NO_2)_2Cu$	Found.
CuO	37·55	37·43

The reaction in this case may therefore be written,—

$$C_5H_3(CH_3)N_4O_3+5H_2O=3CO_2+2NH_3+CH_3NH_2+C_2H_5NO_2.$$

It will be seen that this reaction proves the commonly accepted view that uric acid is not an hydroxyl but an imide acid.

In order further to establish the relative position of the methyl radical, it seemed to me of chief importance to follow it through oxidation in alkaline and acid solution, and thus determine its relation to allantoin and alloxan or paraban.

Methylallantoin. $C_4H_5(CH_3)N_4O_3$.

Methyluric acid is readily oxidized in alkaline solution, according to the method of Claus and Emde.* The solution must be dilute with but a small excess of alkali, the potassic permanganate added slowly in exact molecular proportion. As soon as the manganese dioxide has separated, it must be filtered rapidly with the aid of the pump, and the filtrate slightly acidified with acetic acid. I then found it most advantageous to evaporate as quickly as possible on the water bath to small volume. After standing twenty-four hours the methylallantoin crystallizes out in clusters of radiated prisms. These separated from the mother liquor by pressure, and recrystallized several times from hot water, form clear distinct monoclinic prisms, closely resembling ordinary allantoin. They are readily soluble in hot water, sparingly in cold; almost insoluble in alcohol, hot or cold, and insoluble in ether. These crystals melt with decomposition at 225°.

In spite of many variations of the method, I could obtain in this way but fifteen per cent of the theoretical yield. From the mother liquors evaporated to a syrup, alcohol separates a potash salt, probably of methylallantoic acid. On account of its uninviting character it was not further examined.

Methylallantoin dried at 100° gave, on analysis,—

* Berichte Deutsch. Chem. Gesellsch., vii, 226.

0·2362 grm. gave 0·1092 grm. H_2O, and 0·2978 grm. CO_2.

	Calculated for $C_4H_5(CH_3)N_4O_3$.	Found.
C	34·89	34·39
H	4·65	5·13

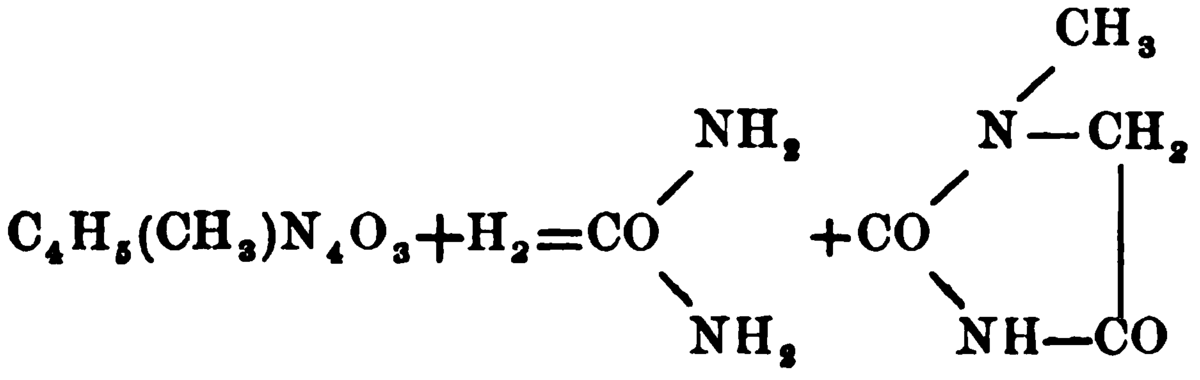
This substance is apparently isomeric with that described by Grimaux under the name Pyruvil.*

Silver nitrate gives in a hot saturated solution on the cautious addition of ammonic hydrate, a crystalline precipitate consisting of needles or short prisms. This salt is readily soluble in hot water, more sparingly in cold. By spontaneous evaporation of the cold solution, tolerably perfect crystals of the trimetric system were obtained. This compound may be dried, without decomposition, at 100°, and gave then on analysis,—

0·1668 grm. left on ignition 0·0646 grm. silver.

	Calculated for $AgC_4H_4(CH_3)N_4O_3$.	Found.
Ag	38·71	38·61

Bäyer† has shown that allantoin, when heated with hydriodic acid, breaks up into urea and hydantoin; and it was evident that methylallantoin should give an analogous reaction. I therefore heated methylallantoin with concentrated hydriodic acid, following the directions given by Bäyer.‡ When the reaction appeared to be ended, the liberated iodine was reduced with sulphide of hydrogen, and the hydriodic acid removed by plumbic carbonate. The filtrate gave on evaporation, after standing for some time, clear crystals, which, freed from the syrupy mother liquor, and recrystallized from water, formed transparent prisms, readily soluble in water or alcohol, and giving no precipitate with zincic chloride. Their melting point I found to be 144°–145°. The quantity at my disposal was insufficient for analysis, but there can be no doubt of the identity of this substance with methyl hydrantoin described by Neubauer§ as resulting from the action of baric hydrate upon creatinine, inasmuch as he gives these properties and the melting point 145°. The reaction may, therefore, be written,—



* Berichte Deutsch. Chem. Gesellsch., vii, 1790.

† Ann. Chem. u. Pharm., cxvii, 178. ‡ Ibid., cxxx, 158. § Ibid., cxxxvii, 288.

Once, as the action of the hydriodic acid was longer continued, I obtained a substance crystallizing in broad rhombic plates, readily soluble in water, sparingly soluble in alcohol, which gave a precipitate with an alcoholic solution of zincic chloride. These crystals melted at 105°, and sublimed readily at 100°. They were evidently sarcosine formed from the decomposition of methylhydantoin.

Oxidation of Methyluric Acid with Nitric Acid.

By the oxidation of methyluric acid with nitric acid, a solution is obtained which gives a deep red coloration on warming with ammonic hydrate. From this solution, however, I have as yet been unable to isolate a crystalline product. By spontaneous evaporation in the air, a sticky syrup is obtained, which does not solidify, even after long standing *in vacuo* over sulphuric acid. Alcohol dissolves this residue, the solution remains clear after the addition of ether, and on evaporation again leaves an uncrystallizable syrup. I have been equally unsuccessful in separating by stannous chloride or sulphide of hydrogen a crystalline alloxantine or dialuric acid. Oxidation with potassic chlorate and hydrochloric acid, according to the method of Schlieper,* gave the same result. These reactions were sufficient to give a qualitative proof that the solution did not contain ordinary alloxan. I therefore attempted to prepare from this solution a methylalloxanate in form fit for analysis. I first tried with baric hydrate to form the barium salt. The ordinary method, following closely the directions of Schlieper,† gave me, however, a salt containing but a trace of nitrogen and with percentages of barium, carbon, and hydrogen, closely approximating those required by a basic baric mesoxalate, $BaC_3O_5.BaO_2H_2$. At the same time a strong smell of methylamine was perceived. If a smaller quantity of baric hydrate were added in the cold, and then alcohol in excess, a barium salt was thrown down which contained nitrogen, but it could not in this way be obtained of constant composition. Plumbic hydrate seemed to determine the formation of the methylalloxanate, but no better results were obtained. The silver salt blackened too rapidly to admit of analysis.

The lime salt is the only one I have been able to prepare with constant composition. Methyluric acid is dissolved in as small a quantity of nitric acid of 1·42 sp. gr. as possible, the solution somewhat diluted, and the excess of acid neutralized with calcic carbonate in the cold. The solution is then allowed to stand *in vacuo* for some time, to free it from carbonic dioxide, afterwards diluted with six or eight volumes of alcohol and filtered. The cautious addition of ammonic hy-

* Ann. Chem. u. Pharm, lv, 261. † Ibid., 272.

date to the filtrate throws down a bulky semi-gelatinous precipitate, which, well washed with alcohol, and dried at 100°, forms an amorphous powder, which has a faint pink color,—undoubtedly caused by a trace of alloxan. The dry salt was soluble in cold water, though with some difficulty.

Analysis gave for substance dried at 100°—

1. 0·1778 grm. gave 0·1125 grm. $CaSO_4$.
2. 0·2275 grm. gave 0·1446 grm. $CaSO_4$.
3. 0·3049 grm. gave 36·8 c.c. nitrogen at 21°·5, and 762·1 mm. press.

	Calculated for $C_4H(CH_3)N_2O_5Ca$	Found. 1	2	3
Ca	18·87	18·61	18·69	
N	13·21			13·68

The analyses 1 and 2 were made with different preparations.

Inasmuch as the chief point was to prove the formation of methylalloxan by this oxidation, I distilled the calcium salt, prepared in the manner described, with potassic hydrate in a current of steam. The ammoniacal distillate readily gave the characteristic isocyanide reaction by heating with alcoholic potash and chloroform. It was neutralized with hydrochloric acid, evaporated, and from the residue the methylamine chloride separated by absolute alcohol. An analysis of the platinum salt gave—

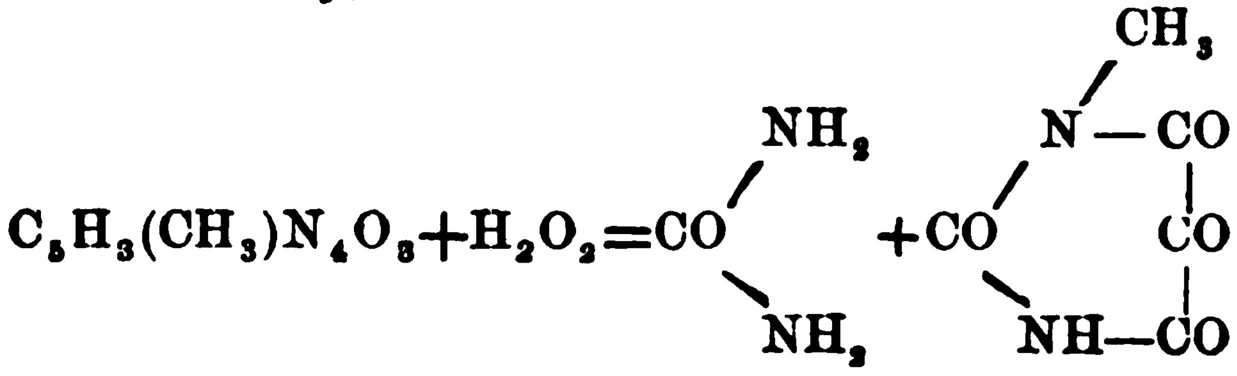
0·2160 grm. left on ignition 0·0902 grm. platinum.

	Calculated for $(CH_3NH_3)_2PtCl_6$	Found.
Pt	41·61	41·76

Thus proving that the calcium salt contained the group $=N-CH_3$.

In further confirmation, I was able to isolate common urea as the secondary product of the methylalloxan formation. After oxidizing with hydrochloric acid and potassic chlorate, the excess of acid was driven off by evaporation at gentle heat, the potassic chloride separated with absolute alcohol, and the alcoholic solution evaporated to a syrup. The cautious addition of strong nitric acid caused the separation of abundant crystals of urea nitrate in characteristic form. The base, set free as usual with baric carbonate, after recrystallization from water, melted at 129°-130°.

The reaction may, therefore, be written—



Methylparaban, $C_3H(CH_3)N_2O_3$.

Although methylalloxan is so unstable in the presence of bases, in acid solution it possesses remarkable stability. It may be boiled for some time with strong nitric acid, or with hydrochloric acid and potassic chlorate before the red coloration with ammonia disappears. On prolonged boiling (about an hour) with strong nitric acid, the oxidation is complete, and the solution contains methylparaban. For its preparation I have found it most advantageous to boil methyluric acid with five or six parts of nitric acid of sp. gr. 1·3, until a drop taken out gives no coloration with ammonia. The excess of acid is then driven off on the water bath, the syrupy residue diluted with a little water, and well shaken out with ether. On distilling off the ether, a syrup remains which soon crystallizes in shining radiated prisms, which are recrystallized from hot water. They are somewhat difficultly soluble in cold water, readily in hot; soluble in alcohol and ether. The substance melts at 149°·5, sublimes very slowly at 100°, and at higher temperature with great readiness. For analysis, the air-dried substance was heated three hours at 100°; during that time 0·2260 grm. lost 0·0030 grm.

1. 0·1714 grm. gave 0·2333 grm. CO_2.*
2. 0·2160 grm. gave 0·0785 grm. H_2O, and 0·2629 grm. CO_2.

	Calculated for $C_4N_2H_4O_3$	Found. 1	2
C	37·50	37·12	37·48
H	3·13		4·04

The substance gives no precipitate with calcic chloride, even after the addition of ammonic hydrate. On warming the ammoniacal solution, a precipitate falls not wholly soluble in acetic acid. Argentic nitrate precipitates it only in concentrated solution. The silver salt prepared from concentrated solution, with the cautious addition of ammonic hydrate, crystallizes in prismatic needles; quite readily soluble in hot water, sparingly in cold. Under the microscope it crystallizes from hot aqueous solution in rhombic plates. It may be dried at 100° without decomposition. It gives on analysis,—

0·1210 grm. left on ignition 0·0556 grm. silver.

	Calculated for $AgC_4N_2H_3O_3$.	Found.
Ag	45·95	45·95

There can be no doubt that this substance is identical with that obtained by Dessaignes† from creatinine, which was first recognized by Strecker‡ as methylparaban. Dessaignes gives

* The hydrogen in this analysis was lost.
† Ann. Chem. u. Pharm., xcvii, 343. ‡ Ibid., cxviii, 164.

no melting point, but the description given corresponds perfectly with the substance I have obtained; the only difference being that I find the substance quite readily soluble in ether, whereas he gives it as somewhat soluble only.

Although I must postpone all discussion of the structure of uric acid until the investigation upon which I am at present engaged is farther advanced, I may perhaps be pardoned if I consider briefly the structure of urea which must of necessity form the foundation of any formula of uric acid. It certainly would not have occurred to me that any such consideration of its structure were necessary had not Professor Mallet in his recent paper on uric acid and its derivatives in this Journal,* adopted the formula $C\begin{matrix}NH_2\\NH\\OH\end{matrix}$, which was proposed several years ago at about the same time by Wanklyn and Gamgee† and Gibbs.‡ Professor Mallet hardly discusses in his paper the facts bearing upon its structure, but contents himself with pointing out the simplicity which he believes this formula will give to its complex derivatives,—a style of argument serviceable enough, where there is little or no choice upon other grounds, but certainly not to be trusted, if opposed by direct synthetic reactions.

The facts remain, as far as I know, essentially as they were when the whole matter was reviewed by Heintz.§ Basarow‖ proved in Kolbe's laboratory the formation of urea from ammonic carbonate and carbamate. Natanson¶ showed that it was formed by the action of ammonia upon carbonyl chloride and ethyl carbonate, and his results were afterward confirmed by Neubauer and Kerner.** By these syntheses urea is shown to be directly connected with carbonic acid as its amide by the three principal general reactions for the formation of amides, and no formula but $CO\begin{matrix}NH_2\\NH_2\end{matrix}$ can explain these reactions without the gratuitous resort to molecular rearrangement. Very recently the reaction with carbonyl chloride has been employed by Michler†† in the formation of fourfold substituted ureas: $CO\begin{matrix}Cl\\Cl\end{matrix}+\begin{matrix}HN(C_2H_5)_2\\HN(C_2H_5)_2\end{matrix}=CO\begin{matrix}N(C_2H_5)_2\\N(C_2H_5)_2\end{matrix}+2HCl$, leaving no possible doubt of the symmetrical distribution of the hydrogen atoms in urea.

Against these syntheses but two facts have been urged:

* This Journal, March, 1876, p. 185.
† Journ. Chem. Soc., II, vi, 25.
‡ This Journal, Nov., 1868, p. 289.
§ Ann. Chem. Pharm., cl, 67.
‖ Zeitschr. für Chem., 1868, 204.
¶ Ann. Chem. Pharm., xcviii, 287.
** Ann. Chem. Pharm., cl, 342.
†† Berichte Deutsch Chem. Gesell., vii, 1664.

first, the monobasic character of urea, and secondly Wanklyn and Gamgee's oxidation with alkaline permanganate.

As for the basicity of urea, Heintz* has already shown that basicity does not always correspond to the number of amide nitrogen atoms, and that amidogen, like hydroxyl, is largely dependent for its character upon the nature of the radical to which it is attached. As especially pertinent he instances oxamide, which is neutral although undoubtedly a diamide. An entirely different case in its nature, although perhaps still more to the point is guanidine $C\begin{matrix}NH_2\\NH\\NH_2\end{matrix}$, which is monobasic only. According to every analogy, therefore, the observed basicity of urea is but the normal behavior of carbamide.

The experiments of Wanklyn and Gamgee† were five in number. Two were made upon urea, two upon ammonium salts, and one upon acetamide. They found with an excess of permanganate that urea gave up all its nitrogen as gas, while the nitrogen of the ammonia and of acetamide was oxidized to nitric or nitrous acid. It may well be questioned, I think, whether these results are sufficient to form the basis of any generalization as to the behavior of "admitted amides," still granting that urea is thus distinguished from all other amides the proof is yet to be brought that the formula $C\begin{matrix}NH_2\\NH\\OH\end{matrix}$ possesses any advantages in explaining this observed decomposition. What experimental facts, what analogies, what plausible theory even can be given to justify the assumption that the nitrogen atoms in $CO\begin{matrix}NH_2\\NH_2\end{matrix}$ and $C\begin{matrix}NH_2\\NH\\OH\end{matrix}$, under the conditions employed by Wanklyn and Gamgee, would differ so fundamentally in their behavior? Anomalous as the decomposition of urea may be, it certainly is not to be explained by so simple a device as the substitution of one imide nitrogen for an amide. If this anomalous behavior should be established by further investigation of other diamido compounds, it would not be the first case in which the mono-carbon compounds differed essentially from their higher homologues.

I have thus briefly given my reasons for dissenting from Professor Mallet's assertion that the structure of urea is by no means settled. I can not but think it established by evidence as unequivocal as our present methods of research are capable of giving.

* Loc. cit., p. 74. † Journ. Chem. Soc., 1868, p. 25.

Harvard College Laboratory, Sept., 1876.

ART. XLVII.—*Notice of a Meteorite, from Madison Co., N. C.;* by B. S. BURTON, University of East Tennessee.

THIS meteorite was placed in my hands for examination by Professor F. H. Bradley, who also furnishes the following facts in regard to its history:

"The mass was found in August, 1873, on land of Robert Farnesworth, near Duel Hill, Madison Co., North Carolina. It was lying on a hillside where it had been used, probably, by the first settlers of the land in supporting a corner of a rail fence, now rotted away. It is said to have weighed, when first found, about twenty-five pounds. Two or three pounds of 'specimens' had been hammered off before I secured it, most of which could not be recovered. Mr. Farnesworth reported that a similar mass weighing about forty pounds had been found about a mile farther west, before the war, perhaps about 1857, which had since disappeared, probably has become buried in rubbish. Efforts to find it again were unsuccessful."

This meteorite consists of metallic iron, of a rounded irregular shape, with the usual coating of magnetic oxide, and measuring $9 \times 6\frac{1}{2} \times 3\frac{1}{2}$ inches, and weighed twenty-one pounds. Over the surface at various points was a small bead-like deliquescence of iron chloride. A portion was cut off at a machine shop, though only after considerable trouble, and described by the machinist as "the toughest piece of iron" he had ever handled. After polishing, and by the action of acid, the usual markings appeared, though rather indistinct; and, at the same time, were developed distinct particles of Schreibersite irregularly disseminated over the surface, which by continued action of the acid stood out more prominently.

Specific gravity $= 7{\cdot}46$. Iron not passive. Dissolves in hydrochloric acid, without liberating sulphuretted hydrogen, leaving a very slight, black, carbonaceous residue, which contained SiO_2, Fe, Cr, Ni, P.

The following result was obtained on about one gram of the iron:

Iron	94·24
Nickel	5·17
Cobalt	0·37
Phosphorus	0·14
Copper	trace
Residue	0·15
	100·07

ART. XLVIII.—*On a Recent Discovery of Carboniferous Batrachians in Nova Scotia;* by J. W. DAWSON, LL.D., F.R.S.

1. *General Remarks.*

THE erect Sigillariæ enclosed in the sandstone overlying coal-group 15 of Section XV, Division 4 of the South Joggins section, are perhaps the most remarkable repositories ever discovered of the remains of Paleozoic land animals. As I have shown in discussing their character in my memoirs on the South Joggins Coal Formation,* and my "Acadian Geology," some of these trees became embedded in sandy deposits, and being rendered hollow by decay of their inner bark and the crumbling of their woody axes, remained for a long time as open holes or pits, gradually filling with vegetable debris and the wash of rains and land floods. They thus became places of habitation for land snails and millepedes, and pit-falls into which the smaller batrachians, prowling for prey among the undergrowth of the coal forest, fell and were unable to extricate themselves. In this way the successive layers of deposit became stored with skeletons of batrachians which they have retained in an admirable state of preservation.

Only one sandstone at the Joggins is known to contain these reptiliferous trees, though erect Sigillariæ are known at more than sixty different levels, and many of these erect stumps have been broken up in the hope of making such discoveries. In the past summer, however, shells of *Pupa vetusta* were found by Mr. Albert J. Hill and the writer in an erect tree in Section XXVI of Division 4, about 800 feet higher in the series; and of course where these shells occur remains of other land animals may also be discovered.

Since the discovery by Sir Charles Lyell and the writer of the remains of *Dendrerpeton Acadianum* in one of the erect trees of group 15, I have several times visited the locality, and have endeavored to take advantage of the exposure of new trunks by the encroachments of the sea. In the summer of 1859 I took down a second stump which afforded nine skeletons of four species. as well as remains of Millepedes and shells of Pupa. In 1860, I dissected two other stumps, which yielded six additional skeletons including two new species. In the whole six batrachian species were more or less perfectly represented, and were described by Prof. Owen or myself. Mr. Scudder subsequently made a careful study of the remains of Millepedes, and referred them to five species belonging to two genera.† In the present year another tree very richly stored

* Journal of Geological Society of London, vols. ix, x, xi, xvi, xviii, xix.

† Air-breathers of the Coal Period, 1863. Acadian Geology, 1868, pp. 362 and 495. Scudder in Memoirs of Boston Soc. of Nat. History, 1873.

with remains was obtained, and its contents will form the subject of the present communication. Two others were extracted for me by the kindness of Mr. Hill, superintendent of the Cumberland Mine, but proved to be filled merely with sandstone without animal remains. This is an illustration of the fact that, even in this bed, only certain trees remained open long enough to become burial places of land animals.

All the remains found in these singular repositories are those of air-breathing animals, except certain worm-like bodies of uncertain nature, which Mr. Scudder suggests may be remains of Leeches. Further, as the reptiles which fell into these pits could have been only such as were capable of walking on land, the erect trees contain none of the ichthyic and elongated forms which have been described from Ireland, from Germany and from Ohio.* Such forms no doubt existed in Nova Scotia, but could not be laid up in coffins formed of Sigillaria trunks. The species preserved in these are therefore all of more or less lizard-like form, and have well developed limbs. Some of them, as we shall find, are also remarkable for ornate cuticular appendages, more akin to those of modern lizards than to those of batrachians. Again, though we know from the footprints of *Sauropus unguifer*,† found in Cumberland County at no great distance from the Joggins, and from those of *Sauropus Sydnensis*‡ found in Cape Breton, as well as from the osseous remains of the alligator-like *Baphetes*, that there were large terrestrial Labyrinthodonts in the coal swamps of Nova Scotia, these were of course too bulky to fall into the erect Sigillariæ; consequently the remains found are those of the smaller species only.

The state of preservation of the specimens is also peculiar. All the bones of each specimen are sure to be present; but inasmuch as most of the carcases had time to decay completely before they were finally covered up, the bones are often much scattered, and have apparently fallen into the interstices of the vegetable fragments on which they lay, so that the skeletons are usually disarticulated, and the bones, though individually perfect, are so entangled in the matrix that it is impossible to uncover the whole of them. In other, though rare cases, the body seems to have been covered at once, and its soft parts, and especially the skin, being either preserved by the tanning action of the vegetable matter, or converted into adipocere, remain in a coaly state, and completely cover the bones, so that these cannot be extracted except in fragments and by the destruction of the cuticle which invests them. Thus, while these remains afford the greatest facilities for the detailed and

* By Huxley, Von Meyer and Cope. † Geological Magazine, vol. ix.
‡ Acadian Geology, p. 358.

even microscopic examination of the parts, they do not often furnish skeletons with their members *in situ*, as in many of those described by Von Meyer, Huxley and Cope.

The tree of 1876 was found by me in "the reef" or extension of the sandstone seaward, and near the low-water mark. The upper part of the stump, probably filled with sandstone, had been removed by the waves, but about two feet of the lower part remained. It was extracted with as much care as possible by two miners with picks and crowbar, and the disk-like fragments, into which it naturally split, were carried up to the foot of the cliff and subsequently numbered and dissected at leisure. In the hurry of working against time to escape the tide, the men it seems left in the hole a portion of the lowest layer, and a fragment of an upper one. The former was afterwards removed by Mr. J. C. Russel of Columbia College, New York, and the latter was found by Mr. Hill. Both have been kindly placed in my hands by these gentlemen, so that the whole of the material has been collected and carefully labelled, in such a manner as to keep together the parts belonging to each skeleton.

This tree was about eighteen inches in diameter, and in the lower part was partially flattened by lateral pressure, so that its diameter in one direction was only a little over a foot. The material filling the somewhat thick coaly bark may be described as a more or less arenaceous silt or soil, blackened with vegetable matter, and replete with fragments of carbonized bark, mineral charcoal and fine vegetable debris. There are also numerous leaves of *Cordaites*, and abundance of the fruits which from their frequent occurrence in such hollow trees, I have elsewhere named *Trigonocarpum sigillariæ*. In some places the sediment was finely laminated, the laminæ being often much contorted. In other places the earthy matter existed in patches or interrupted layers, nearly free from vegetable matter, and especially abundant toward the sides of the trunk. The cementing substance is in general carbonate of lime, many portions of the mass effervescing freely with an acid, but in some spots there are hard concretions of pyrite. The material has evidently been introduced gradually, in small quantities at a time, and the earthy matter seems to have run down the sides, spreading more or less toward the center; but in general accumulating around the circumference. The number of skeletons recovered in a more or less complete state was no less than thirteen in all, belonging probably to six species, besides other bones contained in Coprolites, and several Millepedes, and shells of *Pupa vetusta*, the latter almost entirely in the lowest layers.

The first animal introduced was a specimen of *Hylerpeton Dawsoni* Owen, whose bones and scutes, after decay of the

connecting parts, had slid down the slope of silt from one side toward the center of the space. Next, after a few inches of filling, came a specimen of *Dendrerpeton Acadianum* Owen, whose bones lie along the center of the layer and nearly in one plane. Above this a large flake of bark had fallen in, forming an imperfect floor over the remains. Then, after an inch or two of carbonaceous matter had been deposited, came a somewhat flat surface which seems to have remained uncovered for some time, and on this lie the *disjecta membra* of three skeletons belonging to *Dendrerpeton Acadianum*, *D. Oweni*, and a new species of *Hylerpeton.* Above this was a confused mass of considerable thickness, in which were found another specimen of the new *Hylerpeton*, and remains representing a third animal of the same or an allied genus, also four specimens of *Hylonomus Lyelli*, and portions apparently of an immature *Dendrerpeton.* Still higher in position, was a layer with large portions of the cuticle of a *Dendrerpeton*, probably *D. Acadianum*; and above this, at the surface of the stump, were some remains and impressions of bones probably indicating another specimen of *Dendrerpeton.* Taking these specimens in the order above given, we may notice the new facts which they have disclosed on a preliminary examination.

2. *Remains of Hylerpeton.*

The sole species of this genus heretofore known, *H. Dawsoni*, was discovered by me in 1860, and was described by Professor Owen from remains so scanty that he expressed considerable doubt as to its affinities. I afterward worked out, from a few fragments of the matrix, the evidence that its teeth were simple, without plicated dentine, that it had a large canine or tusk in the anterior part of the upper jaw, and that it possessed a walking foot. The present specimen throws much additional light on its structure. It had at least twelve teeth in each ramus of the mandible, and they are large in proportion to the size of the animal, bluntly conical and somewhat acuminate, and faintly striate at the apex. The vomerine bones are beset with numerous small blunt teeth. The skull is long, and its bones thin and marked merely with delicate incised lines rather than wrinkles. The forms of the stout ribs and scattered vertebræ would indicate that the body was broad and squat. The skull must have been about two inches in length, the body probably four or five, and there are some small vertebræ which may indicate a short tail. The limbs were large and strong, the femur being an inch and a quarter long, and its shaft a fifth of an inch in diameter and with thick bony walls. The vertebræ are short and biconcave, and with large dorsal spines, the belly was protected by numerous imbricated bony scales of two

kinds, one oblong and narrow, the other broad and obliquely shield-shaped. There are indications of thoracic plates of larger size than the scales. On the whole this species was probably a somewhat clumsy creature, of toad-like form and slow gait, and with a dentary apparatus suited to pierce and crush crusts and shells. It is perhaps significant of its habits, in these respects, that the layers of this tree in which its bones occur are alone those in which shells of *Pupa vetusta* are found.

The second species of *Hylerpeton*, which I may provisionally name *H. longidentatus*, was of somewhat smaller size, with the bones of the skull thinner and more slender, and the teeth very long and sharply pointed, with the apex finely striate but with no corrugation of the dentine. The vomer is covered with minute teeth, and there are long and slender canines. The best preserved mandible shows eighteen teeth which are strongly inclined backward. The scales are very narrow and there is a large thoracic plate. The general form of body may have been as in the last species, but the skull was probably narrower and the feet longer.

Another species of this genus, or belonging to a genus intermediate between it and *Hylonomus*, is represented by a confused mass of bones showing long and narrow jaws, armed with short and blunt teeth, of which, at least thirty occur on each side of the lower jaws. The sculpture of the bones is as in the previous species, but the pulp-cavities of the teeth are smaller and their walls stronger, and they show no sculpture on the apex; in which respects they resemble those of *Hylonomus*. The vertebræ also are more elongated and the femur is a large bone indicating a powerful hind limb. The abdominal scutes are very long and narrow, resembling slender semi-cylindrical rods, a point in which this species differs from all the others found with it, although it resembles some of those found in Ireland and Ohio. This species I would name provisionally, in allusion to the form of its teeth, *Hylerpeton curtidentatum*.

In all these species of *Hylerpeton*, the teeth are simple, and are anchylosed to the bone and placed in linear series in a shallow groove.

3. *Remains of Dendrerpeton.*

The remains of this genus will afford additional facts as to the differences in individuals of various ages, and as to the details of the skeleton in the species *D. Oweni*, previously known by only one imperfect example. The specimen now found would seem to show that it resembled very much the larger species, except in the form of the teeth and scales. But the most interesting facts presented by a cursory examination of the specimens relate to the skin and its appendages. It is

now evident that in addition to the abdominal and gular scales, *Dendrerpeton* possessed thoracic plates of considerable size, resembling those of other Labyrinthodonts. The large mass of skin found in the tree of 1876, taken in connection with the smaller portions found on previous occasions, and described in detail in my "Air-breathers of the Coal-period," enables us to form a very good general idea of the appearance and clothing of the animals of this genus. To the naked eye the skin presents a shining and strongly rugose surface, reminding one of that of modern newts when contracted by immersion in alcohol, though on a coarser scale. Under the lens, the surface appears granular and with a higher power the granulation is seen to result from minute scales imbedded in the cuticle, and much smaller than those, in previous finds, which I have referred to *D. Oweni* and to *Hylonomus.* On some portions of it there are delicate transverse lines about a quarter of an inch apart, and apparently corresponding to those which on the newts and Menobranchus mark the bands of subcutaneous muscles. The bony scales of the abdomen have disappeared, except a few scattered in the matrix. But the most remarkable dermal appendages, are those triangular lappets or frills of which I have in previous papers described detached examples, and have compared them with the gular and cervical lappets and frills of iguanas, geckos and Draco; and which also suggest analogies with the processes that support the gills in perennibranchiate batrachians, and with the lateral folds of the skin in Menopoma. These appendages are flat and of appreciable thickness, about half an inch in length, and an eighth of an inch in breadth, terminating in an edge or obtuse flat point, which seems to have been horny, while the appendage itself must have been flexible. They are marked with small scaly oval areoles or projections, placed somewhat in rows, and each with a minute puncture in its center. The markings on both sides are similar. These appendages are arranged in series along what appears to be the skin of a fore leg, and also in groups apparently on the anterior part of the body, perhaps the neck or shoulder. They appear to be closely connected with a series of much smaller angular points which extend along the edge of the skin near the supposed leg, and probably fringe the sides of the abdomen. The evidence that this integument belongs to *Dendrerpeton Acadianum* is derived from the presence in its anterior part of skull-bones having the markings of that of this species, and from the occurrence of a jaw and other bones in the neighboring matrix. The specimen to which the skin belonged may have been about a foot in length. Taking it in connection with what is known of the skeleton, we can reproduce the external appearance of the animal. It was

lizard-like in form, with a somewhat flat and broad head and strong teeth with folded dentine. Its back was covered with a shining skin filled with microscopic horny scales. Its sides were marked by vertical bands separated by delicate indented lines. Anteriorly it was ornamented with numerous cutaneous lappets or pendants. The sides were bordered with a row of sharp horny points, and the throat, thorax and abdomen were protected by bony scales and plates, the scales of the throat being narrow and small and arranged in a chevron pattern.

Dendrerpeton Oweni probably had the scales of the back and the horny appendages larger in proportion, that is, if I have rightly referred to that species some similar remains to those above mentioned, found in 1859. *Hylonomus Lyelli* had a far more ornate set of cutaneous appendages, as evidenced by remains of skin found associated with its bones, also in 1859.* The tree of 1876 contains no cuticular remains referable to these species.

4. *Remains of Hylonomus.*

The bones of this genus are all, I think, referable to *H. Lyelli*, and to specimens about the size of those previously found. They throw little additional light on its character, except to indicate that it was probably very abundant, and to render it probable that the specimens formerly described were adult. Two of the skulls in the tree of 1876 are better preserved than those previously known, and confirm the statement already made as to the smoothness of the bones and the greater cranial elevation as compared with other batrachians of the Carboniferous period. This is indicated, among other things, by the skulls lying upon one side, which is not found to be the case with the other species.

In the admirable Report by Cope on the Batrachians of the Coal-formation of Ohio,† he places *Hylonomus* in the same family, *Tuditanidæ*, with *Dendrerpeton*. This I think does not express its true affinities. The more elongate and narrow skull, with smooth bones, the differently formed vertebræ, the teeth with non-plicated dentine, the different microscope structure of the bone, the more ornate dermal appendages, all separate these animals from the Labyrinthodonts, and entitle them, as I have formerly held, to a distinct position as an order or sub-order, for which I proposed in 1863 the name *Microsauria*. I observe that in the report on the Labyrinthodonts prepared by Mr. Miall for the British Association in 1873, and in the Tabular View appended to it in 1874, while the group *Microsauria* is retained, *Dendrerpeton* is placed in it, as well as *Hylerpeton*

* Journal Geol. Soc., vol. xvi, also "Air-breathers," 1863.
† Paleontology of Ohio, vol. ii.

and *Hylonomus*. This I think is an error in so far as the first genus is concerned. I may add my continued conviction that *Hylonomus* and its allies present many points of approach to the lacertian reptiles, which I hope in future to be able to work out more in detail.

Several masses of Coprolite, filled with small broken bones, were obtained in breaking up the material surrounding the skeletons. I presume these bones belong to one or other of the smaller species of *Hylonomus;* but I have not yet found any of them to be sufficiently characteristic to warrant any confident statement on the subject. These Coprolites must have been produced by *Dendrerpeton* or *Hylerpeton*, most probably the former.

The above statements must be regarded as imperfect, and preliminary to more detailed description and illustration of the specimens. These will require long and patient work and microscopic examinations of the bones and the teeth, and when this is completed they will be placed in relation, as far as possible, with the remains previously found in Nova Scotia, and with what is known of coal batrachians elsewhere.

I think it quite possible that further examination may enlarge the number of species above mentioned. I have been guided mainly in the reference of the specimens to species by the structure of the teeth and the cranial bones; but some of these may yield new points of difference on further study. As all the specimens are preserved under the same conditions, there is less liability here, than in most cases, to multiply species unduly, in consequence of different states of preservation.

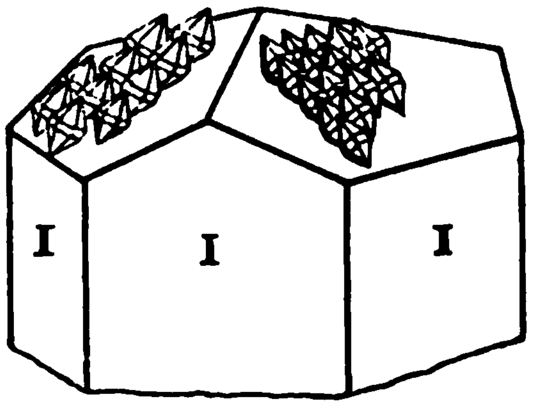
The fact that Cope has been able to catalogue, in his recent Report,* 39 genera of Carboniferous batrachians, including about 100 species, and that these present so wide a range of size, structure and general conformation, affords a very remarkable illustration of that simultaneous occurrence of many forms of one type, which appears in so many other groups of fossil animals; and is particularly striking in this first known group of air-breathing vertebrates, which since 1843 have swarmed upon us from the coal-fields of both continents, and of which we probably know as yet but a small fraction of the species. It remains to be seen whether the Devonian, so rich in its land flora, and which has already afforded remains of insects, may not disclose some precursors of the Carboniferous batrachians.

* Paleontology of Ohio, vol. ii.

ART. XLIX.—*Mineralogical Notes.* No. IV; by EDWARD S. DANA, Ph.D.—*On the association of crystals of Quartz and Calcite in parallel position, as observed on a specimen from the Yellowstone Park.*

THE occurrence of crystals of quartz in parallel position upon the faces of a rhombohedron of calcite was long since described by Breithaupt. The relation of the two minerals is shown in figure 1, given by him; each crystal of quartz has its pyramidal face parallel to the rhombohedron ($-\frac{1}{2}R$) of the calcite. Breithaupt also mentions specimens in which the calcite had been removed, and the resulting form he speaks of under the head of *pseudomorphs* of quartz after calcite, as a "trilling" of quartz.*

1.



A somewhat analogous case was described by Rose† and Eck‡ from Reichenstein in Silesia; more recently vom Rath and Frenzel§ have given a full description, illustrated by a number of figures, of a similar occurrence from Schneeberg, Saxony. In the specimens described by them the calcite rhombohedron ($-\frac{1}{2}R$) was completely enveloped by the quartz. Each rhombohedral face of the former having upon it a pyramid of quartz, united by a pyramidal face, and the extension of these six crystals regularly had produced a form which with its reentering angles appeared to be a trilling (a compound crystal of three combined crystals) of quartz. It was further shown by vom Rath that the calcite alone had determined the position of the quartz crystals, and consequently that the form, which had resulted, was only a *pseudo-trilling.* Both the vertical twinning-plane, and the horizontal plane of the compound crystal were pronounced to be impossible forms with quartz.

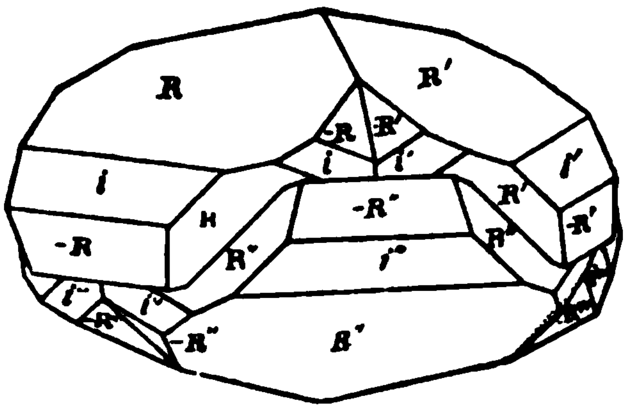
Many cases of the association of crystals of different species in parallel position have been observed (as for example, of albite on orthoclase, of pyroxene on hornblende, of chrysolite and humite, etc.), but the case here mentioned is of an exceptionally anomalous character. It is a matter of some interest, therefore, to note the discovery of a new case of this association of quartz and calcite and one which offers some features not before observed, affording at least a partial explanation of this geometrical relation between the two minerals.

* Berg- u. Hütten. Zeit., 1861, 54.
† G. Rose, Pogg. Ann., lxxxiii, 461.
‡ H. Eck, ZS. G. Ges., xviii, 426.
§ Pogg. Ann., clv, 17, 1874.

The specimen in hand was obtained by the writer in August, 1875, when visiting the Yellowstone National Park in connection with the party of Col. William Ludlow, U. S. A. It was found in the neighborhood of what has been called "Specimen Mountain," a locality which has furnished many fine amethysts, geodes of chalcedony, and fragments of silicified wood. The rock is an igneous conglomerate.

The specimen itself consists mostly of chalcedony, upon the surface of which have been implanted rhombohedrons $(-\frac{1}{2}R)$ of calcite, and finally, as a still later process, the quartz has incrusted both the calcite crystals and simultaneously the exposed surfaces of the chalcedony. In the latter position a simple drusy surface of fine quartz crystals, irregularly planted, has resulted, but the crystals upon the calcite, though unquestionably of simultaneous formation, are all in a similar parallel position, analogous to that shown in fig. 1; the pyramidal faces of the quartz crystals (R or $-R$) being parallel to the rhombohedral $(-\frac{1}{2}R)$ face of the underlying calcite. In some cases a collection of small parallel crystals of quartz form a coating upon each rhombohedral face, but more generally these crystals are so developed as to be united, forming perfectly smooth continuous faces parallel to those of the calcite. Some of the crystals of calcite are half an inch or more in length, and the continuous layer of quartz has a thickness of about $\frac{1}{2}$ mm., completely enveloping them. This coating may be readily removed, leaving the calcite crystal entire. The completed form, as remarked by vom Rath, has a most anomalous appearance, and one likely to puzzle the careless observer.

2.



The general appearance of the crystals is very uniform; it is shown in fig. 2. In the smaller crystals ($\frac{1}{8}$ to $\frac{1}{4}$ inch broad), the symmetry of the planes was nearly as perfect as in the drawing. A comparison of this figure with those given by vom Rath will show that though in the main features similar, still the one here given differs in some most important respects.

The first examination of the crystals suggests the probable existence of the zones (fig. 2) i, $-R$, $-R'$, i': also i, R, R'', i'', $-R''$, $-R^{iv}$; and i', R', R'', i'', $-R''$, $-R'''$. The three cases as they are continued around the crystal are obviously repetitions of the same series of planes. A more critical study of them, however, by the aid of the reflecting goniometer, shows that they are really only *pseudo-zones*, although it is seen at the same time that the deviation from perfect parallelism is very slight. It is in fact a remarkable case of *pseudo-symmetry*.

The following angles were measured in these "zones," as they may for convenience be called. A double-telescope goniometer was employed for the purpose, though the character of the planes was not such as to allow of the highest degree of accuracy.

1. Zone i, $-R$, $-R'$, i'

$i \wedge -R = 113° \ 12'$	$i \wedge -R' = 143° \ 48'$	$-R \wedge -R' = 149' \ 28'$
$i' \wedge -R' = 113° \ 10'$	$i' \wedge -R = 143° \ 45'$	$i \wedge i' = 77° \ 29'$

2. Zone i, R, R'', i'', $-R''$, $-R^{\text{iv}}$

$i \wedge i'' = 102° \ 8'$	$R \wedge R'' = 124° \ 2'$	$-R'' \wedge -R^{\text{iv}} \ 149° \ 13'$

Supposing for the moment that the two series of planes mentioned are true zones, and also that, as appears at first sight to be the case, the whole crystal is a complex *twin*, it is obvious that the twinning-plane for the two upper crystals of quartz must be a plane in the zone i, $-R$, etc., and must either halve the angle $i \wedge i'$, or which is the same thing $-R \wedge -R'$, or else be normal to this bisecting plane. Similarly, for either crystal above and the one diagonally below, the twinning-plane must also lie in the zone i, $+R$, etc., and must be either that plane which bisects the angle $i \wedge i''$, and $R \wedge R''$, or one at right angles to it.

For the first case the measured angle of $-R \wedge -R' = 149° \ 28'$, gives $38° \ 24'$, that is, $141° \ 36'$ or the angle between the twinning-plane and the prism i. Again, the measured angle $77° \ 29'$ for $i \wedge i'$ gives $38° \ 44\frac{1}{2}$, that is, $141° \ 15\frac{1}{2}'$ for the inclination of the twinning-plane upon the prism i.

For the second case, the angle of $R \wedge R'' = 124° \ 2'$ gives $128° \ 53'$ for the angle between the prism and the twinning-plane, or $141° \ 7'$ if the twinning-plane is normal to the composition-plane. Again the angle of $i \wedge i'' = 102° \ 8'$ gives for the same angle $128° \ 56'$, or, on the other supposition, $141° \ 4'$. If we compare this angle ($141°$–$142°$) thus obtained with the inclination of the prism upon the successive planes of the zone between i and R having the general symbol $m\text{-}\frac{m}{m-1}$, we are surprised to find that it agrees quite closely with that which is required for $i \wedge 2\text{-}2$, viz. $142° \ 2'$. This plane 2-2, one of the most commonly occurring of all the various forms of quartz is thus *approximately the twinning-plane.* In the first case we obtained $141° \ 36'$ and $141° \ 15\frac{1}{2}$, and in the second case $141° \ 7'$, and $141° \ 4'$. There is here some discrepancy, but considering the relation of the crystals the correspondence is very remarkable.

The conclusion to which we arrive then, is this: that although the position of the quartz is unquestionably determined by the

calcite, nevertheless the resulting form possesses a remarkably high degree of symmetry, and approximates very closely to that which would be produced by a twinning parallel to the plane 2-2. The two adjacent crystals are united by the twinning-plane, and the two diagonally opposite by a plane normal to this, but the same law of twinning applies to both cases.

It can hardly be questioned that this fact, that by this method of grouping the form of the quartz approximates so closely to a form which might well exist independently, must be at least a partial reason why it is here placed in so remarkable a geometrical relation with calcite.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Size of Hydrogen Atoms.*—Annaheim has described a simple lecture experiment in which the coloring power of fuchsin and cyanin is made use of to illustrate the extraordinary divisibility of matter. To form an idea of the amount of coloring matter visible to the naked eye, he weighed out 0·0007 gram fuchsin ($C_{20}H_{19}N_3HCl$)—a fragment about half a millimeter in diameter—dissolved it in alcohol and diluted the solution to a liter. In each centimeter, therefore, there was contained 0·0000007 gram coloring matter; and yet, placed in a burette one centimeter in diameter, the color showed distinctly even from a distance. A single drop of this solution—of 35 to the cubic centimeter—in a test-tube placed on white paper showed a distinct red color. Hence it follows that the eye can perceive ·00000002 gram fuchsin. But if we assume that each drop contains only one molecule, and it cannot contain less, then, since the molecular weight of fuchsin is 337·5, the maximum weight of a hydrogen atom is $\frac{1}{337 \cdot 5}$ of 0·00000002 gram, or 0·000000000059 gram! The same experiment with cyanin ($C_{28}H_{35}N_2I$) whose molecular weight is 526, leads to a similar result. One milligram dissolved in a liter of alcohol, will give for each drop 0·0000000285 gram. From this, it appears that the weight of the hydrogen atom cannot exceed 0·000000000054 gram, a curiously close coincidence.—*Ber. Berl. Chem. Ges.*, ix, 1151, September, 1876. G. F. B.

2. *On the Atomic Weight of Selenium.*—Pettersson and Ekman have made an extended research on the atomic weight of selenium, analyzing for this purpose calcium, magnesium and silver selenates, ammonium-aluminum selenate, silver selenite, and selenous oxide, all of the greatest attainable purity. Silver selenite on ignition yields a beautiful crystalline crust of pure silver. Hence by weighing the salt, igniting and again weighing, the data for determining the atomic weight are obtained. As a mean of seven analyses, the atomic weight obtained was 79·01. By

reduction of selenous acid by sulphurous acid, collecting and drying the precipitate and weighing it, another determination was made. The mean of five determinations, which agree well with each other, is 79·08. The authors, believing the latter determination to have more weight, assign the atomic weight 79·08 to selenium, which they believe correct to the first decimal place.—*Ber. Berl. Chem. Ges.*, ix, 1210, September, 1876. G. F. B.

3. *An improved Nitrogen-measuring Tube.*—ZULKOWSKY has improved the apparatus for measuring nitrogen by volume, which was proposed by Dumas. It consists of two tubes, 1·8 cm. diameter, and 58 cm. long, one of which is closed at the top, while both are drawn down at bottom so as to slip a rubber tube over the ends. The closed tube is graduated, and it, as well as the other tube, has a small lateral tube attached 44 cm. from the top, the one on the closed or measuring tube for connecting the apparatus with the combustion tube, the other furnished with a quetschhahn, for drawing off the liquid within. The two tubes are held parallel and upright and form a U tube. By turning the measuring tube down it may be filled with a potash solution. The combustion is proceeded with as usual, carbon dioxide evolved from hydro-sodium carbonate being used first to drive out the air. As the bubbles rise through the potassium hydrate, they are more and more perfectly absorbed. When this process is finished the substance is heated and the nitrogen is allowed to come over. Its temperature is noted, and, after making the level of the liquid the same in both tubes, its volume is read and reduced to the normal pressure and temperature. Analytical results obtained with it are given which are exceedingly accurate.—*Liebig's Ann.*, clxxxii, 296, September, 1876. G. F. B.

4. *On the Physical properties of Gallium.*—BOISBAUDRAN, having prepared a decigram of very nearly pure gallium, has made some careful observations on its physical properties. Its fusing point is about 29·5°, so that the heat of the hand liquefies it. When liquid, it exhibits the phenomena of surfusion to a remarkable degree. It has remained liquid for more than a month, the globule being frequently broken and reunited again by a steel blade, in a room the temperature of which often fell below the freezing point. Contact with a bit of solid gallium however, solidified it at once. Liquid gallium is very mobile, appears covered with a pellicle when exposed to the air, and adheres strongly to glass. Only a few degrees below its fusing point, the metal is hard and remarkably tenacious; but it may be cut with a knife as aluminum may. It crystallizes with facility, crystal facets being developed by treatment with hydrochloric acid. It does not oxidize at a red heat except upon the surface and it does not volatilize. Its spark spectrum gives the two well-known bright lines of wave length 417 and 403·1; its flame spectrum only the 417 line and this difficultly. Its density, approximately, is 4·7; thus placing it, like its other physical properties, between aluminum and indium. Its atomic weight places it there, probably, also.—*J. Phys.*, v, 277, September, 1876. G. F. B.

5. *New Vapor-density method for Substances of high Boiling-points.*—The labor consequent upon the determination of a vapor density in the case of a substance of high boiling point by the method of Deville and Troost, has led VICTOR MEYER to contrive a new method which is simple and easily applied, using no more material than the method of Hofmann and yet making determinations up to the boiling point of sulphur, 444·2°. In place of mercury, Wood's fusible metal, fusing at 70° C. is used. The principle involved consists in volatilizing a small but accurately weighed quantity of the substance in a vessel previously completely filled with the fusible metal, and then determining the volume of the vapor by heating in sulphur vapor and measuring the quantity of metal which has overflowed. The vessel employed is a bulb of about 25 c. c. capacity having a fine point at top and a tube 6 to 7 mm. diameter and 6·7 centimeters long issuing from the bottom and bent upward to just above the point. The author has determined as data, the specific gravity of the alloy at 444°, and its expansion coefficient between 98° and 444°; one gram at 98° increases 0·1092 c. c. at 444°. The substance is placed in a small tube, which it must completely fill, and is introduced into the bulb which is then completely filled with the metal, care being taken to exclude air-bubbles. After heating to the temperature of boiling water, the excess of metal on the tube is removed and the whole is weighed to decigrams. The bulb is then fastened to a wire, and the whole is plunged in the vapor of boiling sulphur till the temperature is uniform. It is then removed, allowed to cool partially and weighed. The difference in weight is the amount of overflow. Knowing the expansion-coefficient, its volume is easily calculated and reduced. All the data are now known, and in calculating the density the author uses the formula

$$D = \frac{S \cdot 14146000}{(a - 0{\cdot}036b)\ (P + \tfrac{1}{3}p)},$$

in which S is the weight of the substance used, a the weight of the metal used, b that which overflowed, P the barometric height, p the difference of level within and without. The density of diphenyl thus obtained is 5·33; cal. 5·32. Of anthracene 6·24; cal. 6·15. Of triphenylamine 8·49; cal. 8·48. Of anthraquinone 7·22; cal. 7·19. Of paradibrombenzene 8·14; cal. 8·15.—*Ber. Berl. Chem. Ges.*, ix, 1216, September, 1876. G. F. B.

6. *On Glycero-phosphoric acid from Brain Tissue.*—THUDICHUM and KINGZETT have described some of the salts of glycero-phosphoric acid obtained from kephalin, a substance prepared by the former from brain tissue. When boiled with baryta water, barium salts of certain fatty acids, barium glycero-phosphate, and one or two nitrogenous bases result. The lead, calcium and barium salts of glycero-phosphoric acid are described. A singular compound of the barium salt, called an alcoholo-hydrate, was obtained by precipitating it by alcohol, which contains probably three molecules of alcohol and six of water united to one of acid

glycero-phosphate. The authors give certain theoretical views concerning the kephalins, myelins and lecithins in the brain, all of which yield this acid.—*J. Chem. Soc.*, xxx, 20, July, 1876.

G. F. B.

7. *Chemistry: General, Medical, and Pharmaceutical, including the Chemistry of the U. S. Pharmacopœias. A manual of the general principles of the science, and their applications in medicine and pharmacy*; by JOHN ATTFIELD, Ph.D., F.C.S., etc. Seventh edition. Revised from the Sixth (English) edition by the Author. 668 pp. 12mo. Philadelphia, 1876. (H. C. Lea.)—Dr. Attfield's book has in nine years appeared in seven successive editions, of which the present has been adapted by the author expressly to the convenience of American students in medical chemistry. It is an excellent book in many respects, and evidently meets the wants of the class of students for whom it was prepared. The modern nomenclature and philosophy of chemistry and the metric system are used in the work.

B. S.

8. *A Systematic Hand-book of Volumetric Analysis, etc.*; by FRANCIS SUTTON, F.C.S., etc. Third edition. 438 pp. 8vo. Philadelphia, 1876. (Lindsay and Blakiston.)—The former editions of Mr. Sutton's excellent hand-book have long been in the hands of chemists. The second edition has for some time been out of print, however, and therefore the third edition is the more acceptable to working chemists who will find in it a careful digest of this department of chemical literature brought down to September, 1876. It bears marks of careful revision throughout. The sections on the analyses of potable waters and sewage have been completely revised and much enlarged by Mr. W. Thorp, long connected with the Pollution of Rivers Commission, as Chief Chemical Assistant under Drs. Frankland and Armstrong. The methods of analysis of potable waters introduced by these chemists are in this volume carefully collated from the original sources and presented in clear and exact statements. The chapters on gas analysis by Prof. McLeod have also been revised and extended. Under this head the author would have added to the value of his hand-book by introducing the eudiometrical apparatus described by Mr. C. W. Hinman in this Journal for September, 1874, (vol. viii, p. 182), which combines the good points of Russell and Williamson's, Doyère's, and Gibbs' apparatus with others of his own in a very compact form, giving accurate results with a very important saving of time and labor and the great convenience of enabling the chemists to conduct the analyses in any ordinary room. This book well deserves the highest commendation for its fullness, accuracy and systematic arrangement of the entire subject. It is a pleasure for once to see an American edition of an English science-manual escape the mutilation too frequently committed in the so-called "reprints from the last London edition."

B. S.

9. *Chemia Coartata, or the Key to Modern Chemistry*; by A. H. KOLLMYER, A.M., M.D., etc. iii pp. 12mo. Philadelphia. (Lindsay and Blakiston).—This is an attempt to present some of

the leading facts of chemistry in a tabular form. The facts are arranged in classified groups under the heads, Substance, Synonyms, History, Obtained form, Equations, Properties and Tests. "The main object of the author has been to compress into as small a space as possible everything connected with the study that deserves attention, and to give no more explanatory matter than is actually required to render each subject perfectly intelligible." It is evident from this statement that the author attempts too much for the beginner and accomplishes too little for the proficient student.

B. S.

10. *Lissajous' Curves.*—M. MERCADIER has introduced some improvements in the apparatus for producing these curves. Two large tuning forks are maintained in vibration by an electric current circulating around a magnet placed between the prongs. The pitch is regulated approximately by two weights of five or six hundred grams and a variation of an entire octave is thus attained. The main improvement is in the apparatus for varying the pitch by small amounts without stopping the forks. To one of the prongs is attached a small split nut through which a screw passes with a loaded head. The latter instead of being round has four projecting arms by means of which it may be turned with the finger or a small hammer. The distance of the center of gravity of the screw from the end of the fork is thus altered and with it the rapidity of the vibration. It is easy to see that the period of vibration increases with the amplitude, and although this change is very small, yet the optical method is so sensitive that it shows it clearly.—*Journal de Physique*, v, 309. E. C. P.

11. *Mechanical Equivalent of Heat.*—The committee of the British Association appointed to determine this constant, report progress as follows: Dr. Joule has been engaged in further measurements by means of the friction of water, and as the average result of sixty experiments gives 772·2 in British gravitation units at Manchester. The greatest deviation from the above average is $\frac{1}{200}$. Experiments have yet to be made on the capacity for heat of the calorimeter, the provisional computation being based on the experiments of Regnault. The greatest possible error from this source is probably $\frac{1}{300}$ and that from the incorrect boiling point of the thermometers $\frac{1}{400}$. The maximum value of these two corrections might amount to 4·5 in the above values. The experiments of Hirn on the friction of water have given him 786, but the average of his results from the friction, boring and crushing of metals gives 776. Assuming that the above experiments and those made by Dr. Joule for the committee on Standards of Electrical Resistance are to be relied on, the unit issued by it would appear to have a resistance one-fortieth too small. Inasmuch as the locality in which the experiments for that unit were conducted was open to objection, it appears desirable that they should be conducted under more favorable circumstances.—*Nature*, xiv, 476.

E. C. P.

12. *Ohm's Law.*—Prof. MAXWELL presented to the British Association at their last meeting the Report of the Committee for Testing Experimentally the Exactness of Ohm's Law. The prin-

cipal difficulty arises from the fact that the current generates heat, so that it is extremely difficult to keep the temperature constant with different currents. Since the resistance is the same whichever way the current passes, the resistance, if not constant, must depend upon even powers of the intensity of the current through each element of the conductor. Hence if we cause a current to pass in succession through two conductors of different sections, the deviations from Ohm's law will be greater in the conductor of smaller section, and if the resistances are equal for small currents they will be no longer equal for large currents. The first test was by means of five coils each of thirty ohms resistance, and two others to complete the bridge. A difference of over four-millionths in the relative resistance of any two of these coils proved to be measurable. According to Ohm's law, if either four of these were connected two and two, the resistance should be equal to that of the fifth coil. By mercury cups these were connected in such a way that each in turn could be compared with the other four. The results showed a small deviation from the law, probably due to irregularity in the conducting power of the connections since it was not confirmed in the more searching tests afterward applied.

A second method was next adopted in which weak and strong currents were alternately passed through two wires of nearly equal resistance but one short and fine the other coarse and long. The currents were changed thirty, and sometimes sixty times a second, so that the wire could not sensibly change in temperature in the interval. Since the current has far greater intensity in the fine than in the coarse wire the deviation should be correspondingly great. Combining these resistances with two coarse wires in a Wheatstone's bridge, if equilibrium occurred it must be due to either one of two causes. Either Ohm's law is true and there is no difference in the effect of the two currents, or the apparent equilibrium must arise from a succession of equal and alternate currents those in one direction due to the stout wire, those in the other to the fine wire. The latter case is easily tested by reversing the direction of the weaker current when its effect should add to that of the other. Currents are employed in some cases so powerful as to heat the finer wire to redness, but whenever the action was steady the reversal of the weaker current gave no result. Mr. Chrystal, by whom the experiments were performed, has put his result in the following form: If a conductor of iron, platinum or German silver of one square centimeter in section has a resistance of one ohm for infinitely small currents, its resistance when acted on by an electromotive force of one volt (provided its temperature is kept the same) is not altered by so much as the millionth of the millionth part.

It is seldom, if ever, that so searching a test has been applied to a law which was originally established by experimeut, and which must still be considered a purely empirical law, as it has not hitherto been deduced from the fundamental principles of dynamics.

But the mode in which it has borne this test not only warrants our entire reliance on its accuracy within the limits of ordinary experimental work, but encourages us to believe that the simplicity of an empirical law may sometimes be an argument for its exactness, even when we are not able to show that the law is a consequence of elementary dynamical principles.—*Nature*, xiv, 452. E. C. P.

13. *Protection of Buildings from Lightning.*—Prof. MAXWELL suggests another system of protecting buildings quite unlike that in common use. Attention is generally especially devoted to the two ends of the conductor, to secure an elevated and pointed terminal above and a good connection with moist earth below. This system seems calculated rather for the benefit of the surrounding country and for the relief of clouds laboring under an accumulation of electricity, than for the protection of the building on which the conductor is erected. What we really wish is to prevent the possibility of an electric discharge taking place within a certain region, say in the inside of a gunpowder manufactory. An electric discharge cannot occur between two bodies unless the difference in their potentials is sufficiently great compared with the distance between them. This may be avoided by connecting all these bodies by good conductors as wire ropes. But this is not necessary if the exterior is covered with a good conductor. Thus, if the roof, walls and ground floor are covered with thick sheet-copper, no electrical effect could be produced inside by a thunder storm. No earth connection would be necessary and the building might even be insulated by a layer of asphalte. Any long conductor, as the gas or water pipes, should be connected with the sheet copper. Accordingly a telegraph wire should not pass inside the building, since this connection would render it useless. An entire covering is by no means necessary. A network formed by carrying a stout copper wire around the foundation, up each of the corners and gables and along the ridges would probably be sufficient for any thunderstorm in this climate. If there are any gas or water pipes, they should be connected with the wires, but if there are no such metallic connections with distant points, it is not necessary to take any pains to facilitate the escape of the electricity into the earth.—*Nature*, xiv, 479. E. C. P.

14. *On the Tidal Retardation Argument for the Age of the Earth.*—Mr. JAMES CROLL, LL.D., F.R.S., of the Geological Survey, read a paper "On the Tidal Retardation Argument for the Age of the Earth." Many years ago Sir William Thomson demonstrated from physical considerations that the views which then prevailed in regard to geological time and the age of our globe were perfectly erroneous. His two main arguments, as are well known, were—first, that based on the sun's possible age; and secondly, that based on the secular cooling of the earth. More recently he has advanced a third argument (Trans. Geol. Soc of Glasgow, vol. iii, p. 1), based on tidal retardation. It is well known that owing to tidal retardation the rate of the earth's rotation is slowly diminishing, and it is, therefore, evident that if we

go back for many millions of years we reach a period when the earth must have been rotating much faster than now. Sir William's argument is, that had the earth solidified several hundred millions of years ago the flattening at the poles and the bulging at the equator would have been much greater than we find them to be. Therefore, because the earth is so little flattened it must have been rotating, when it became solid, at very nearly the same rate as at present. And as the rate of rotation is becoming slower and slower, it cannot be so many millions of years back since solidification took place. A few years ago I ventured to point out (*Nature*, Aug. 21st, 1871; Climate and Time, p. 335,) what appeared to be a very obvious objection to the argument, and as the validity of the objection, so far as I am aware, has never been questioned, I have been induced to believe that the argument referred to had been abandoned. But I find that Professor Tait in his work on "Recent Advances in Physical Science," restates the argument as perfectly conclusive, and makes no reference whatever to my objection. As the subject is one of very considerable importance, I may be permitted to direct attention to the objection in question, which briefly is as follows:

It has been proved by a method pointed out a few years ago (Philosophical Magazine, May, 1868, pp. 378–384, February, 1867, p. 1830; Climate and Time, Chap. xx; Transactions of Geological Society of Glasgow, vol. iii, p. 153), and which is now generally admitted to be reliable, that the rocky surface of our globe is being lowered, on an average, by subaerial denudation at the rate of about one foot in 6,000 years. It follows as a consequence from the loss of centrifugal force resulting from the retardation of the earth's rotation, occasioned by the friction of the tidal-wave, that the sea-level must be slowly sinking at the equator, and rising at the poles. This, of course, tends to protect the polar regions, and expose equatorial regions to subaerial denudation. Now, it is perfectly obvious that, unless the sea-level at the equator has, in consequence of tidal retardation, been sinking during past ages at a greater rate than one foot in 6,000 years, it is physically impossible that the form of our globe could have been very much different from what it is at present, whatever may have been its form when it consolidated; because subaerial denudation would have lowered the equator as rapidly as the sea sank. But in equatorial regions the rate of denudation is, no doubt, much greater than in the temperate regions. It has been shown in the papers above referred to that the rate at which a country is being lowered by subaerial denudation, is mainly determined, not so much by the character of its rocks, as by the sedimentary carrying power of its river systems. Consequently, other things being equal, the greater the rain-fall the greater will be the rate of denudation. We know that the basin of the Ganges for example is being lowered by denudation at the rate of about one foot in 2,300 years, and this is probably not very far from the average rate at which the equatorial regions are being denuded. It is therefore evident that subaerial denudation is lowering the equator as

rapidly as the sea level is sinking from loss of rotation, and that consequently we cannot infer from the present form of our globe what was its form when it solidified. In as far as tidal retardation can show to the contrary its form may have been as oblate as that of the planet Jupiter when solidification took place.

There is another circumstance which must be taken into account. The lowering of the equator by the transference of materials from the equator to the higher latitudes must tend to increase the rate of rotation, or, more properly, it must tend to lessen the rate of tidal retardation.

15. *Sound*, by JOHN TYNDALL. 448 pp. 8vo. Third edition, revised and enlarged. New York. 1876. (D. Appleton & Co.)—The Preface to the new edition of this valuable work opens with the statement of the author that in preparing this new edition of his work he has amended, as far as possible, its defects of style and matter, and paid at the same time respectful attention to the criticisms and suggestions which the former editions called forth. The most important new matter introduced is an account of the author's investigations on the acoustic transparency of the atmosphere in relation to Fog-signaling. The preface contains an account of work done in the same line in America, and especially by Prof. Henry, after which follow arguments against Prof. Henry's explanation of the observed phenomena. The distinguished author repeats in his preface his former remarks on the "injurious influence still exercised by authority in science," that it is "not only injurious but deadly when it cows the intellect;" when if any one's intellect has been thus cowed in this free age, no one is to be blamed but himself.

16. *Entwickelung der theoretischen Ansichten über die gepaarten Schwefelverbindungen* von GEORGE A. SMYTH (of Amherst, Mass.) 122 pp. 8vo. Berlin. 1876.

II. GEOLOGY AND MINERALOGY.

1. *Report on the Geological Map of Massachusetts, prepared by* W. O. CROSBY, Assistant in the Laboratory of the Boston Society of Natural History. 52 pp. 8vo. Boston, 1876.—The map here referred to is one colored for the Centennial Exposition at Philadelphia. Mr. Crosby lays down the distribution of Norian, Huronian, Mont-Alban, and Paleozoic areas in the State, gives an account of the rocks, characterizing them, stating briefly their kinds and their supposed stratigraphical relations. Of the rocks of the State, the remark is made at the outset, that they "are mainly crystallines, which are believed to belong wholly to the Eozoic [Archæan] era;" but no satisfactory evidence on this question of age is brought forward except that with regard to the formation underlying unconformably the Primordial of Braintree. The fossiliferous limestone of Bernardston, containing large crinoidal stems, and referred by Hall, Billings and others to the Helderberg formation (lower or upper), and which underlies mica slate and quartzyte, seems to be included by the author with the Mont-

Alban, the statement being made that the argillite of Bernardston is of this age; if not so intended, this most interesting formation is left unnoticed. Of the age of the limestone and associated rocks in Berkshire, Mr. Crosby says: "it seems probable that it will ultimately prove to be, as an increasing number of geologists are inclined even now to regard it, older than the Primordial." Such a conclusion is at variance with the fact of the existence of Lower Silurian fossils at some Vermont localities in the limestone. The pamphlet closes with an account of the Geology of the Nashua Valley, by L. S. Burbank.

2. *Geological Survey of Indiana; Seventh Annual Report on the Surveys made during the year* 1875, E. T. Cox, State Geologist. 302 pp. 8vo.—This Report treats of the special geology of Vigo and Huntington counties, by Mr. Cox; of Riply and Jennings counties, by W. W. Borden; of Orange, by M. N. Elrod and E. S. McIntire; of Vanderburg, Owen and Montgomery counties, and portions of Clay and Putnam counties, by J. Collett; and contains also a report on the depth and temperature of the lakes of Northern Indiana, by G. M. Levette, and another on the Flora of the Wabash Valley, by J. Schenck, M.D., and on Fossil marine plants of the Carboniferous, by L. Lesquereux. The volume commences with a General Report by the head of the Survey, which includes a review of the principal observations of the year, together with information on the Coals of the State, with the results of numerous analyses, on the distribution of the millstone grit and on its whet-stone bed in Orange Co., with a list of the fossil plants in this bed, as furnished by Prof. Lesquereux.

Mr. Levette's survey of the Lakes states that the ancient shores of many of the lakes afford a chalky material, which is nearly pure carbonate of calcium (with 3 or 4 per cent of magnesia), the beds of which are in some places 20 or 30 feet thick. It affords no evidence of organic origin, and hence is stated to be probably a chemical deposit. An *artesian boring* at Fort Wayne has reached a depth of 3,000 feet; the first 88 feet were of drift; and then it entered a Niagara limestone, and continued through limestone and calcareous shale to 2,500 feet; thence, through soft calcareous rock to its present bottom in the Lower Silurian. The temperature at 90, 100, 1,000, 1,500 and 2,635 feet, registered by the thermometer was 51½° F. Another well at Wabash commenced in the Niagara limestone and was continued in limestone and calcareous shale to a depth of 2,270 feet, without getting a flow of water. At 100, 500, 1,000, and 2,270 feet the temperature of the water obtained was 50½° F. The thermometer was one made for the purpose by James Green of New York. Mr. Cox says that "The inference to be drawn from the uniform temperature of these wells is that they are filled with water that comes from an upper stratum." In another well 1,923½ feet deep at Terre Haute, penetrating the Coal measures and Devonian, and stopping, it is believed, in the Niagara, the temperature obtained throughout was 81° F.; and this is referred to waters from the lower part of the well filling it.

3. *Geological Map of Scotland*, by ARCHIBALD GEIKIE, Director of the Geological Survey of Scotland. Edinburgh. (W. & A. K. Johnston, Geographers and Engravers to the Queen).—Professor Geikie has contributed much by his own labors to the knowledge of Scottish geology, and thereby, aided also by the labors of others on the survey and of independent investigations, he has been enabled to make great improvements in preparing this new edition of the map. It is well colored, and presents to the eye illustrations of various problems of great interest to general geology. It is of convenient portable size, measuring about one foot ten inches by two feet ten.

4. *Huronian of Canada.* Letter from Mr. A. R. C. SELWYN, Director of the Geological Survey of Canada, to J. D. Dana, dated Montreal, October 28th, 1876.—Referring to Article XXXVI in the October number of your Journal, it seems to me that Mr. Bradley has quite misunderstood what I wrote him respecting the so-called Huronian Series of Canada. I am not aware that I ever mentioned Sir William Logan's name to Mr. Bradley, in the matter; and certainly if Sir William held the views attributed to him, he never informed me of the fact. When Mr. Bradley sent me a copy of his map, in acknowledging the receipt of it I remarked that I could not agree in the propriety of including the whole of the Huronian Series in the Silurian System, though I saw no reason for supposing it to be older than the Cambrian—Harlech and Longmynd rocks—of the British Survey, which are supposed to occupy a position between the Primordial and the Laurentian, which is also the position assigned to the Huronian series in America. I informed Mr. Bradley that the Mistassinni Lake Huronian band was, in some part of its course, from 150 to 200 miles wide, (not 300 miles as stated), and that in mineral character part of it very closely resembled the altered Quebec group of Canada, notably in the chromiferous serpentine, magnetite and dolomite. If, however, it is an established fact that in Minnesota and Wisconsin the same Huronian rocks are unconformably covered by the Potsdam sandstone it becomes certain, whatever their mineralogical resemblances may be, that they cannot belong to the Quebec group, and we have not, so far as I know at present, any evidence which would warrant us in classing them with the Silurian.

5. *Geological Survey of Michigan. Fossil Corals, by* Dr. C. ROMINGER, *State Geologist.* 154 pp. 8vo, with 55 plates.—An "advance copy, unrevised by the author," has been received, and it gives us great pleasure to announce the appearance of a work that will so largely meet the necessities of American paleontological science in the department of Fossil Corals. The illustrations are albertypes, and beautiful specimens of the art, being among the best from the engraving office of Julius Bien of New York. The science of the country owes much to the Geological Board of the State of Michigan, that they authorized the preparation and publication of so complete and well-illustrated a Report on this hitherto much neglected branch of American Paleontology.

6. *Memoirs of the Geological Survey of India. Palæontologica Indica.*—Published by order of the Governor General of India in Council, under the direction of Thomas Oldham, LL.D., Superintendent of the Geological Survey of India. Vol. i, Parts 2, 3 and 4 (1875), contain the continuation of the memoir on the Jurassic Ammonitidæ of Kutch, by William Waagen, Ph.D. They include plates 5 to 60, and finish the volume.

The *Memoirs of the Survey* in octavo, vol. xi, part 2 (226 pages), contain, a paper of 226 pages by Mr. Wynne, on the *Trans-Indus Salt region*, Kohat District, which is illustrated by several fine plates, showing the displaced and folded character of the rocks. The folds, which are often of great complexity, include the Nummulitic and other Tertiary beds. The Rock Salt belongs to the lower part of the Nummulitic strata, and is referred to the early Eocene. In some places, and especially near Bahádur Khêl, the salt forms high detached hills, cliffs, and naked exposures for a distance of four miles, with a width exceeding a quarter of a mile; and to the eastward for four miles, there are large crater-like holes, proving its presence now or formerly beneath the surface. Throughout the district it frequently appears in precipitous outcrops within the elliptical boundaries of the Nummulitic limestone. The salt is, for the most part, remarkably pure, without admixture with potash salts. The maximum thickness of the salt rock is not less than 1,230 feet. It is associated with gypsum, and to the eastward is somewhat bituminous at top. The underlying strata are not known; and the absence of fossils from the salt beds leave some doubt as to its precise age. A large colored geological map accompanies the memoir.

The *Records of the Geological Survey*, vol. ix, part 1, 1876, contain a brief Annual Report, together with an account of the Geology of Sind, by Wm. T. Blanford, the rocks of which, thus far observed, range from the Infra-nummulitic, supposed to be Lower Eocene to the Pliocene and more recent.

7. *Detritus of Rivers.*—The Liverpool Geological Society held its first annual meeting of the session on the 10th instant, when the retiring president, Mr. T. Mellard Reade, C.E., F.G.S., delivered his annual address. The subject was an interesting one, being a calculation of the amount of solid matter removed annually from the surface of England and Wales in solution, in rain, or rather river water. The result of the calculations, which were of an elaborate nature, founded upon the analysis of water given by the Rivers' Pollution Commission in their Sixth Report, and the rainfall chart prepared by Mr. Symons, showed that it would take 13,000 years to remove, in this manner, one foot in depth of solid matter over the entire surface of England and Wales. This calculation was compared with others prepared by Mr. Reade, of the soluble denudation of the great river basins of Europe, viz: the Danube, the Rhine, and the Rhone. As throwing light upon the age of sedimentary deposits, the calculations taken, together with the amount of matter annually brought down in river water

in suspension in the form of mud, are extremely interesting, and Mr. Reade deduced from them that the minimum amount of time which must have elapsed since the first sedimentary rocks we know of were laid down is, in round numbers, 500 millions of years, thus supporting the views of Lyell, Hutton, and other great geologists, as to the immense age of the world.—*Nature*, Oct. 26.

8. *Mallet's Theory of Volcanic Energy.*—The paper of Prof. Mallet upon volcanic energy, which was translated into German by Prof. A. von Lasaulx, has been somewhat severely criticized in the Göttingen Gelehrte Anzeige by O. Lang. This criticism has recently been fully answered by Prof. Lasaulx. He gives a satisfactory demonstration of the mathematical formula referred to $\left(T = \frac{P\rho}{2}\right)$, that by which Mallet proves that a crushing of the materials of the earth's crust must take place, and shows that it is mathematically complete. Moreover, he convicts Mr. Lang of a total misunderstanding of the question involved, and shows that he himself is alone responsible for the difficulties which he suggests.

9. *Geological reunion at the Paris Exposition in* 1878.—The American Association for the Advancement of Science, at its session on the 25th of August last, unanimously adopted the following resolution:—

Resolved, That a Committee of the Association be appointed by the Chair to consider the propriety of holding an International Congress of Geologists at Paris, during the International Exhibition in 1878, for the purpose of getting together comparative collections, maps and sections, and for the settling of many obscure points relating to geological classification and nomenclature. And that to this Committee be added our guests, Prof. T. H. Huxley of England, Dr. Otto Torell of Sweden, and Dr. E. H. von Baumhauer of the Netherlands, who shall be requested to open negotiations in Europe looking to a full representation of European geologists at the proposed Congress. The said Committee to consist of Prof. William B. Rogers, Messrs. James Hall, J. W. Dawson, J. S. Newberry, T. Sterry Hunt, C. H. Hitchcock and R. Pumpelly, in behalf of the Association, with the addition of Prof. T. H. Huxley, Dr. Otto Torell and Dr. E. H. von Baumhauer.

On the same day, at a meeting of the Committee, Prof. James Hall was elected Chairman, and Dr. T. Sterry Hunt, Secretary. A circular has since been issued, which is to appear in English, French and German, and to be distributed to geologists throughout the world, asking their coöperation in this great work of an International Geological Exhibition and an International Geological Congress to be held at Paris in 1878; the precise date of the Congress to be subsequently fixed.

This circular recommends with reference to the objects of the Congress, that the Geological department of the Exposition shall embrace: (1) Collections of rocks, illustrating all points of lithological and geological interest; (2) of fossils, and especially of the Primordial or Cambrian; and (3) of geological maps and sections.

10. *Recent Discoveries of the Brazilian Geological Commission;* by THEO. B. COMSTOCK, Assistant Professor in charge of Geological Department, Cornell University.—The Rio Curupatúba enters the Amazonas from the north at a distance of four hundred miles from the Atlantic coast. A few miles above the confluence of these rivers, on the left bank of the former, is situated the villa of Monte Alegre. From this point, in 1870, while acting as an assistant on the first Morgan expedition from Cornell University, the writer made a trip northwestward across the country over the trail leading to the hamlet of Ereré.* Messrs. Herbert H. Smith and Phineas P. Staunton were of the party. Shortly after crossing the Igarapé de Ereré, a small river which communicates with the Curupatúba through the lower portion of the Igarapé do Paitúna, we discovered an exposure of Devonian shales yielding a few fossils, afterward identified by Mr. Richard Rathbun. He found them to be related to species characteristic of the Hamilton Period in New York State, one being only a variety of *Discina Lodensis* Hall, while the others were new species of the genus *Lingula.*† In his review of the geology of this region, Professor Hartt remarks:‡ "The great repository of fossils is the sandstone, which . . . . appears to form bands a few inches in thickness, interstratified with the shales in their upper part. [N. B.—These shales are probably not the equivalents of those previously mentioned, for they are exposed two miles north of the little village of Ereré.—T. B. C.] . . . . ." "The fossils most abundant in the sandstone are the Brachiopoda, which are represented by twenty species belonging to the following genera: *Terebratula*, *Vitulina*, *Tropidoleptus*, *Spirifera*, *Cyrtina*(?), *Retzia*, *Streptorhynchus*, *Chonetes*, *Orthis*, *Rhynchonella* and *Lingula*, all of which are described in the paper of Mr. Rathbun."

The structural geology of the Ereré-Monte Alegre district was studied with considerable care by Professor Hartt and his assistants on the first Morgan expedition, and further details were determined by himself and Mr. O. A. Derby in the following year (1871). They were unable, however, wholly to unravel some of the more difficult problems presented in that region, for which reason Messrs. Derby, Smith and Freitas, of the Brazilian Geological Commission, have spent the past few months in a thorough survey of the whole area. The importance of the results obtained by them, as reported in a recent letter from Mr. Derby, will be better understood after a brief review of the general physiognomy of the district under consideration.

The villa of Monte Alegre (upper town) is perched upon the top of a comparatively level block of horizontal Tertiary beds,

* See Preliminary Report on the Geology and Physical Geography of the Ereré-Monte Alegre District, by Professor Ch. Fred. Hartt, in charge of the expedition, in Bulletin of the Buffalo Soc. Nat. Sci., January, 1874.

† *L. Graçana* Rathbun, and *L. Stauntoniana* Rathbun, figured and described in his paper "On the Devonian Brachiopoda of Ereré, Province of Pará, Brazil, in Bull. Buffalo Soc. Nat. Sci., January, 1874, p. 259.

‡ Ibid., p. 212.

extending in a curved line to the north and the east. To the southward stretch the broad alluvial Amazonian plains, across which the Curupatúba has cut its way, and through a part of which the lower portion of the Igarapés of Ereré and Paitúna are now flowing. The upper portion of the Igarapé de Ereré and its little tributaries together drain the nearly square Devonian floor, at the southern side of which is situated the Indian village of Ereré. The rocks over the last mentioned area are horizontal or but little inclined, but the square space is partially enclosed by bold *serras* of more complicated structure and of other formations. A series of ridges extending across the southern limit of the plain comprises the serras of Ereré; Aroxi and Aracuré, the western edge is bounded by ranges of low hills; the serra of Tanajurí occupies the eastern end of a row of ridges along the northern side, and the Monte Alegre plateau completes the enclosure. The serra do Paitúna lies off by itself a few miles beyond the southern boundary of the square.

The table-topped hills between Prainha and Almeirim (Serras de Parú), noticed in nearly every account of Amazonian travel, were never examined carefully until Professor Hartt visited them in 1871.* They lie much farther to the east, down the Amazonas from Monte Alegre, and have generally been regarded by travelers as members of the same system of *serras* as the ridges of Ereré, Paitúna and Tanajurí. This view was shown to be erroneous by Hartt,† who examined the westernmost one of this series, known as the serra Parauaquára, and found it to be made up of horizontal strata probably of Tertiary age.

Messrs. Derby and Smith, with Senhor Freitas have now succeeded in resolving the equivalents of the formations outcropping over the Ereré-Tanajurí district, with results of great interest to science. They have discovered a few localities rich in fossils, such being quite uncommon in this tropical region where exposures are few and the rocks very much weathered. The serras, in which the rocks are much contorted, are composed largely of Cretaceous beds extending downward into the upper Paleozoic formations, Carboniferous and Devonian. North of Ereré, they discovered 1000 feet or more of Lower Devonian rocks, underlying those found by Mr. Smith and the writer in 1870. These new beds are mainly *parachronous*‡ with the Oriskany sandstone of North America. Mr. Derby writes that he has obtained from this horizon "seventy-five species, including several characteristic Oriskany species, mixed with true Devonian forms. The Oriskany here is certainly Devonian." This discovery seems very significant in its bearing upon certain theories in connection with "cycles of deposition." An apparent conflict in geognostical and paleontological

* Von Martius, in fact, was the only previous visitor to the serras. He reported (*Reise in Brasilien, IIIer Theil*, *S.* 1326), upon the botany of one of the Serras de Almeirim, but barely touches its geology.

† Bull. Buff. Soc. N. S., ibid., p. 228, *et seq.*

‡ The term *parachronous* was suggested by the writer (Reconn. N. W. Wyoming, etc., Jones, 1874, p. 143) as convenient to apply to beds of the same *relative* age, when true *synchronism* is uncertain.

records is thus harmonized, as it appears. The same number of species is reported from the Upper Devonian of the Ereré district, and the Carboniferous beds have yielded a similar number to Mr. H. H. Smith, among which there are probably some entirely new forms. The latter formation appears to extend widely over South America, as elsewhere. The fossils identified by Mr. Derby, which were collected on the Morgan expeditions, came from outcrops in the vicinity of Itaitúba, on the Rio Tapajos,* and these were regarded by him as closely related to the Bolivian Carboniferous fauna and to other beds of similar age (Coal measures) in both North and South America and in Europe.† The Cretaceous beds of the serras have afforded many fossils, in places, but no details are furnished by the members of the Imperial Survey.

Professor Hartt, at latest account, was engaged in a personal exploration of the Coal-Measure area in the southern province of Santa Catharina, where characteristic plant-fossils and workable beds of coal are known to exist.‡ The occurrence of coal in the valley of the Amazonas has been suspected; there is probably no region in the world where it could be more advantageously employed, but as yet no exposure of valuable beds has been reported.

11. New Minerals. *Mottramite*, *Roscoelite.*—Prof. H. E. Roscoe has recently described a new vanadium mineral, under the name of *Mottramite.* It occurs as a crystalline incrustation on the Keuper sandstone at Alderley Edge, and at Mottram St. Andrew's, Cheshire, England. The incrustation is usually thin, but sometimes 3 or 4 mm. in thickness. Occasionally in minute crystals of a black velvety appearance in the mass, but by transmitted light yellow. Also compact, opaque, and of a purplish brown color. Luster resinous. Streak yellow. H.=3; G.=5·894. The mean of two analyses gave V_2O_5 17·14, PbO 50·97, CuO 19·10, (Fe, Zn, Mn)O 2·52, CaO 2·13, MgO 0·26, H_2O 3·63, moisture 0·22, silica 1·06=97.03. The formula is written $(PbCu)_3V_2O_8+2H_2(PbCu)O_2$ analogous to erinite and dihydrite.

Prof. Roscoe has also examined the *roscoelite*, named by Dr. Blake, and since described by Dr. Genth (see this Journal, III, xii, 31, 32). The formula to which his analysis leads is as follows:—$2AlV_2O_8+K_4Si_9O_{20}+aq.$; this is quite a different result from that obtained by Dr. Genth.—*Proc. Roy. Soc.*, June 15, 1876.

12. *The "Mexican Onyx."*—Prof. Marianor Bacena, of the Mexican Commission to the Centennial Exposition, has recently published an account of the occurrence and chemical character of the rocks called *Mexican onyx.* The principal deposits are located near the town of Tecalli, in the State of Puebla. It is essentially a carbonate of calcium, containing small quantities of the oxides

* A tributary of the Amazonas, entering the latter from the southwest at Santarem, not many miles above Monte Alegre.

† See paper "On the Carboniferous Brachiopoda of Itaitúba, Rio Tapajos, Province of Pará, Brazil," by O. A. Derby, Bull. Cornell University, (Science), Vol. I, No. 2, where figures and descriptions are given.

‡ Hartt, Geology and Physical Geography of Brazil, 1870, p. 519.

of iron and manganese, to which the variegated colors are due, for which the rock is so much admired. The specific gravity, 2·9, shows that it is aragonite.

III. Botany and Zoology.

1. *Relation of Coloration to Environment.*—Mr. Wallace's oversight about a "*Pelargonium* of Kerguelen's Land," has been pointed out in *Nature* and noted in this Journal (p. 400). There is another oversight as to locality, which may as well be corrected, though of no practical consequence. It is in Florida, not "Virginia," that the white pigs are poisoned by Paint-root (*Lachnanthes*), while the black are unaffected. It may be, however, that Mr. Darwin's explanation of the immunity is nearer the mark than Dr. Ogle's, adopted by Mr. Wallace, plausible as the latter is. For if only black hogs are raised, as Prof. Wyman stated, and if the black pigs, by reason of better smell and taste do not eat the root, as Dr. Ogle suggests, what is it "which colored their bones pink?" It may not be so, but Prof. Wyman's account implies that the bones of the black hogs are thus colored. Will some one at the proper localities in Florida investigate this? A. G.

2. *Subradical solitary Flowers in Scirpus.*—The Rev. Thomas Morong, of Melrose, Massachusetts, recently brought me some specimens of my *Scirpus supinus*, var. *Hallii* (olim *S. Hallii*), which he gathered on the borders of Winter Pond in Woburn or Winchester, Massachusetts, late in September. Mr. Wm. Boott had also detected this plant in the same locality. It is interesting to know that this is a New England as well as a Western species. But a higher interest is given by Mr. Morong's discovery that this plant freely produces solitary female flowers in the axils of sheaths or short leaves at the base of the culm. These subradical flowers, apparently produced only at the close of summer, have capillary styles of half an inch to a full inch in length, mostly deeply three-cleft with unequal branches, sometimes three-parted or two-parted nearly to the ovary. The latter sometimes matures an akene which is similar to those of the spikes above. No stamens have been detected in these flowers; but they are found in some imperfect and four to five-flowered subradical spikes which I have occasionally met with, and which are in some sort intermediate between the ordinary and this extraordinary inflorescence. Mr. Morong noticed that the flowers in his specimens were triandrous; but I find that some are diandrous. These long-overlooked subradical flowers are now obvious in most of my herbarium specimens from Illinois, Missouri, and Texas, in those with trifid as well as those with bifid stigmas of the ordinary flowers. I find no trace of subradical flowers in the true *S. supinus* of the Old World, but my specimens are scanty. They occur, however, in a specimen (resembling our American plant) of Griffith's Bengal collection. This American variety, or species, has narrower spikelets and more carinate scales than is usual in *S. supinus*.

A. G.

3. *Dictionnaire de Botanique;* par M. H. BAILLON. *Dessins* de A. FAGUET. Premier fascicule. (5 francs.) Paris: Librairie Hachette & Cie.—This is a large undertaking. The first fasciculus just issued consists of 80 pages, large 4to, double columns, with one chromolithic colored plate (of an *Æschynanthus*) and very many wood-cuts, some of which have done service in the editor's other works. To this we would not object, nor to the more profuse than pertinent illustration of the first article of the book, viz: a privative, by sixteen figures, five to explain its use in the word *acetylédone*, three for that of *asépale*, six for *apétale;* but we do object to the teaching that *Rubia*, *Loranthus* and *Thesium* are destitute of calyx, and that *Asparagus*, *Frittillaria* and *Galanthus* are apetalous. The work is almost exhaustive in plan, is beautifully illustrated, and well printed on excellent paper. The price therefore is low; for those who do not possess a botanical library it should be a boon; for those who do, a great convenience. It is far more needed than the *Histoire des Plantes*, and we are glad that Prof. Baillon has turned his labors in this direction. The list of collaborators already announced, and who have contributed to this fascicle contains good names, the more notable being those of De Seynes, Nylander, Fournier, Bureau, Weddel and Ascherson. Among them is the name of *Rafinesque!* Apparently all botanical names are to be given, the genera in French or Latin form, or in both, generic characters sketched, important genera illustrated, popular names explained or referred, botanical terms defined, and botanical authors biographically noticed. The physiological articles are encyclopœdic; that on *absorption* fills almost six of the large pages, *accroisement* four and a half. Accuracy in such a work is of the first importance, and we may presume that all reasonable pains will be taken. But we notice that, on p. 27, the akene of a Valerian, with its pappus, figures for that of a *composée*, and on p. 41, *Trautvetteria* is named *Actæa spicata*, and Agassiz is said to have died at New York. A. G.

4. *Nuovo Giornale Botanico Italiano* diretto du T. CARUEL. Pisa. Vol. viii. 1876.—This volume was issued in four parts, of unequal size, the first in January, the fourth in October; the journal is apparently well sustained; and, besides the editor's own articles, has papers by De Notaris, Delpino, Arcangeli, Saccardo, etc. A. G.

5. *Flora Orientalis . . . auctore* EDMOND BOISSIER.—The third volume of this important Flora—which failed to reach us seasonably—was published in 1875. It fills 1133 pages, and carries the work on from *Caprifoliaceæ* to *Pyrolaceæ* inclusive; the larger part being occupied by the *Compositæ*, which dominate in the Orient as they do in North America, but under different tribes, the *Inuleæ* and *Cynareæ* taking the lead. *Centaurea* has 182 species, *Cirsium* (*Cnicus*) 74, and *Cousinia* 136, almost all Asiatic. Before the close of 1875 the first part of the fourth volume was likewise issued (280 pages), continuing the *Gamopetalæ*, *Borragineæ* being the largest order. The remainder of this volume may soon be expected. A. G.

6. *On the Barringtoniaceæ*, by JOHN MIERS, F.R.S., etc.—An elaborate memoir of this group of tropical plants, published in the first volume of the new series of the Transactions of the Linnean Society, London, 1875, with nine plates. Mr. Miers insists upon the complete separation of these plants from *Myrtaceæ*, and their independence as a natural order, of ten genera, one of which is a restoration and four newly proposed. The typical genus is reduced to a single species, while the restored *Butonica* has sixteen, and *Stravadium* nineteen. It is interesting to see that a veteran of the author's age has the courage to undertake and the force to execute a work of this sort. The figures, moreover, are all by his hand. A. G.

7. *A Catalogue of the Forest Trees of the United States, which usually attain a height of sixteen feet or more, with notes and brief descriptions of the more important species, illustrating the collection of Forest-tree sections on exhibition by the Department of Agriculture at the Centennial Exhibition, Philadelphia.* Prepared by GEO. VASEY, M.D. (Washington, 1876. 38 pp. 8vo.)—All agree in awarding great credit to Dr. Vasey for the United States exhibition of our native trees and arborescent plants. Making the collection general and as far as possible complete, and stinted both in means and time, he could not undertake to accumulate sections of large trunks, such as those of some State and other exhibits; but his collection was full, systematic, well-displayed, and most instructive. This accompanying pamphlet, very useful in illustrating the exhibition, will still be convenient and valuable for reference. A. G.

8. *Morphology of the Carpellary Scales of Coniferæ.*—The true nature of the female flower of Coniferæ has been an important question among botanists since fifty years, when Robert Brown first announced the doetrine of their gymnospermous character. Without going into details of the history of investigations and theories, it may be stated at once that the very thorough treatment of the question by G. Stenzel, published a few months ago in the Nov. Act. Nat. Cur., vol. xxxviii, as reported by Prof. Eichler in Flora of September 1st, seems definitely to settle the controversy. The result of Stenzel's examination of numerous monstrosities of female flowers of the *Abies excelsa*, obtained at the limit of tree vegetation on the Sudetic Mountains, is that Mohl's view of the structure of the fruit-scale, based on the nature of the double leaf of Sciadopitys, is the correct one. The fruit-scale in *Abies*, and in all *Abietineæ*, in this view consists of two leaves of an undeveloped axis, or branchlet originating in the axil of the bract, and the posterior (superior) edges of these leaves being connate laterally and a little backward, as the lowest pair of leaves or bracts in Coniferæ always are, the leaves turn their back toward the axis of the inflorescence (the cone) and bear on that side one ovule each. In *Cupressineæ*, where the carpellary scale is peltate, and often bears numerous ovules, the same morphological explanation holds good, and even in *Podocarpeæ*

and *Taxineæ*, which have no fruit-scale, we must come to the same conclusion, assuming a virtual suppression of the scale. The greatest difficulty seems to arise from the position of the ovules on the dorsal side of the open carpel, which is not seen in any angiospermous plants; however, the anther-cells, which morphologically correspond to the ovules, are in Coniferæ also borne on the lower side of the stamen-scale; and for further analogy we have to look to the *Cycadeæ*, and, be it boldly announced, to the *Ferns*. *Lycopodiaceæ*, on the other hand, bearing the spore-cases on the upper side of the leaf, cannot be regarded as the progenitors of Coniferæ, as has been thought. The relationship of Coniferæ is with *Cycadeæ* and Ferns, while *Gnetaceæ* become still farther removed from them. The writer of this notice has seen monstrous (proliferous) cones of *Abies Engelmanni*, in Colorado, but only at the upper limit of tree-vegetation, under similar conditions to the European monstrosities. He has also noticed the foliaceous development of the carpellary scales in monstrosities of *Abies Canadensis*, either into a distinct or a more or less connate pair of leaves; but only at the base, not, as in other species, at the top of the cone. G. E.

9. *Species, Genera, et Ordines Algarum. Volumen Tertium: De Florideis Curæ Posteriores.* Auctore J. G. AGARDH. Lund. 1876.—In the present volume, the author reviews the species described in the first, second, and a portion of the third part of volume second of his classic work on algæ, giving frequent emendations, and interpolating the species described since the publication of that volume. The whole forms a volume of 700 pages, and, with the exception of the *Rhodomeleæ* and *Corallineæ*, purports to be a complete monograph of the orders of *Florideæ*. In the execution of the volume, the author has followed the same plan as in the preceding, and the text shows a careful editing, being comparatively free from typographical errors. Twenty species and two genera are either new to the United States or, for the first time, fully described. *Centroceras Oregonense* Ag., seems to be *Centroceras Eatonianum* Farlow, published in the Proc. Am. Acad., March 9, 1875. In the case of some of the species described from California, considering the small amount of material probably at his disposal, Agardh has been, perhaps, a little injudicious in separating as distinct species some forms which had been supposed to be identical with European species, as, for instance, *Sarcophyllis* (*Schizymenia*) *edulis*, taken to be the same as *S. edulis*, of Europe, and *Gymnogongyrus leptophyllus*, supposed to be *G. Griffithsiæ*. It is a well-known fact that species of algæ attain a larger size on the Californian coast than on European shores, and, in estimating whether a species is new, regard should be had to the difference of aspect produced by a more luxuriant growth. *Plocanium coccineum* illustrates this. In a collection of specimens of that species from all parts of the world, any experienced hand could readily pick out the specimens coming from California. Yet, although more luxuriant, no algologist, with the

exception of Kützing, would separate the Californian form as a distinct species. Should the Californian species of Agardh be accepted as genuine, it would go far to overturn the conclusion that, as in the case of phanerogams, so we have a number of species of algæ common to Europe and California, but wanting on the eastern coast of America. The significance of this view is familiar to the readers of this Journal from the writings of Professor Gray. The present volume, except for the preface and occasional foot-notes, might be called a worthy sequel to those which have preceded. But in the preface, Agardh not only denies the fertilizing action of the antherozoids of the *Florideæ*, but even declares that he has not been able to see in the trichogyne anything more than an aborted branch. He completely ignores the brilliant discovery of Thuret and Bornet, and seems to think that the bare announcement that he does not believe it, ought to counterbalance the statements of careful observers. It may be that the neatly dried specimens on the herbarium shelves at Lund do not show clearly the nature of the trichogyne, but the correctness of Thuret's and Bornet's observations have been confirmed by numbers of algologists on the sea shore, and the fertilization of the more simple genera such as *Neuralion*, *Batrachospermum*, *Callithamnion*, etc., has become a common object of class-demonstration in the laboratories of Europe, and at least of one in this country. W. G. F.

10. *Notes Algologiques.* Fascicule I. Par M. M. Ed. Bornet et G. Thuret. Paris, 1876. Small folio.—This is the first portion of a work intended to embody the results of the observations of the late M. Thuret and Dr. Bornet for a long series of years. M. Thuret, during his frequent algological excursions, had a number of elaborate drawings executed, principally by Riocreux, with the intention of publishing them; but, owing to the difficulty of procuring capable engravers, the plan was abandoned. Not, however, wholly relinquishing his plan, he had many less complicated drawings prepared, which, on his untimely death in the spring of 1875, were bequeathed to his friend and co-worker, Dr. Bornet, who was to superintend their publication. The plates of this fascicule are twenty-five in number and, in point of execution, are unequalled by any relating to algæ, excepting those which illustrated Thuret's articles on zoöspores and antheridia in the *Annales*. The work is to algology what the *Carpologia Fungorum Selecta* of the Tulasne Brothers is to fungology. The text is no less rich and complete than the plates. A general description of the reproduction and reproductive organs of different genera precedes the detailed description of the plates, which, in the present fascicule, represent species referred to by Bornet in his *Deuxième Note sur les Gonidies des Lichens*, or which were collected by Schousboe in Morocco and determined by Thuret. The notes are a masterly exposition of the reproduction in the *Nostochineæ* and *Florideæ*, and are so replete with facts that a single reading barely suffices to give a general notion of the contents. Particularly interesting are the description of the reproduction of *Calothrix confervicola*,

and the comparative description of the fruit of the different genera included by older writers under *Callithamnion*. The fertilization of *Polyides*, similar to *Dudresnaya*, is referred to, but will probably be figured later. The work of Agardh is an encyclopædia in which one may find the name of any *Floridiæ* more easily perhaps than in any other. The work of Bornet and Thuret has a different object. Determination of names by a somewhat artificial grouping is subordinated to a true knowledge of the relations of algæ through a study of their minute anatomy and development.

W. G. F.

11. *Nuttall Ornithological Club.*—Bulletin No. 3, for September, contains, besides various miscellaneous notes, a paper by J. A. Allen on the Decrease of Birds in Massachusetts, one by Dr. Elliott Coues on the number of Primaries in Oscines, and one by William Brewster on the Yellow-bellied Woodpecker, *Sphyrapicus varius.*

12. *A Course of Practical Instruction in Elementary Biology*, by T. H. HUXLEY and H. N. MARTIN. Second edition, revised. 280 pp. 8vo. London and New York. 1876. (Macmillan & Co.)

13. *On Casting the skin in Menopoma Alleghaniense;* by A. R. GROTE. The following observation has been recently made by Mr. Grote on a specimen in the aquarium of the Buffalo Society of Natural Sciences. The wide mouth is opened several times to its fullest extent, by which means the skin is parted on the lips, and then rolls backward over the head. Before this, the transparent pellicle was observed to be loosely surrounding the surface of the animal from which it had separated. By short jerky movements the *Menopoma* then withdrew its front legs from the old skin. The animal next moved in a forward direction, withdrawing itself from the skin, which was shoved back by the water until the skin was folded against the hind legs. The *Menopoma* then turned shortly round on itself, and, taking the skin in its mouth, drew it over the hind legs and tail. The skin was retained in the mouth and subsequently swallowed. The whole operation was quickly performed.

IV. ASTRONOMY.

1. *Intra-Mercurial Planet.*—In his discussion of the theory of Mercury, Mr. Le Verrier found reason to believe in the existence of a planet, or of matter enough to form a planet, revolving around the sun within the orbit of Mercury. An observation of Mr. Weber, of Peckeloh, of a black round spot seen by him last April upon the sun, has revived the question, though Weber is proved, by observations at Madrid and Greenwich, to have seen only an ordinary sun-spot.

From nearly thirty observations within the last 115 years of spots supposed to have been such a planet, Mr. Le Verrier selects ten as most worthy of confidence, because the spot is reported to have been in motion. Of these, five are in March and October,

and they are fairly represented by a planet revolving in an orbit either in 33·02 or in 27·96 days; less exactly by an orbit of 24·25 days, or one of 40·32 days.

At Mr. Le Verrier's request the sun was observed early in October, both in this country and in Europe, but without result. He thinks a transit possible on the 22d of March next, if the orbit is one of 33·02 days. No other spring transit occurs with that supposition before 1885. For an October transit we must wait till about 1881. None of the observations made use of by Le Verrier, however, appear to be so free from doubts as to establish the existence of a planet within the orbit of Mercury. H. A. N.

2. *November Meteors.*—On the morning of November 14th, between twelve and one o'clock, the sky at New Haven was partly clear. Out of about twelve meteors seen, three might be called conformable to the radiant in Leo. Shortly after one o'clock the sky became wholly overcast. H. A. N.

IV. Miscellaneous Scientific Intelligence.

1. *On the Extirpation of Species;* by Prof. Alfred Newton. (From his Address, Brit. Assoc., as published in Nature of Sept. 14.)—And now to follow out the idea with which I began. Having touched on the two chief zoological events of the year, let us see if they do not suggest something that will not be beneath your consideration for the remainder of this address. I have spoken of the certainty of the expedition from which we now welcome our friends being succeeded by others of similar character. We shall hardly be indulging any vain imagination if we ask ourselves what we may look forward to as regards their reports; and to one point we may perhaps usefully apply ourselves.

What if a future *Challenger* shall report of some island, now known to possess a rich and varied animal population, that its present fauna had disappeared? that its only mammals were feral pigs, goats, rats, and rabbits—with an infusion of ferrets, introduced by a zealous "acclimatizer" to check the seperabundance of the rodents last-named, but contented themselves with the colonists' chickens? that sparrows and starlings, brought from Europe, were its only land-birds, that the former had propagated to such an extent that the cultivation of cereals had ceased to pay—the prohibition of bird-keeping boys by the local school-board contributing to the same effect—and that the latter (the starlings) having put an end to the indigenous insectivorous birds by consuming their food, had turned their attention to the settlers' orchards, so that a crop of fruit was only to be looked for about once in five years—when the great periodical cyclones had reduced the number of the depredators? that the goats had destroyed one half of the original flora, and the rabbits the rest? that the pigs devastated the potato-gardens, and yam-grounds? This is no fanciful picture. I pretend not to the gift of prophecy; that is a faculty alien to the scientific mind; but if we may reason from the

known to the unknown, from what has been and from what is to what will be, I cannot entertain a doubt that these things are coming to pass; for I am sure there are places where what is very like them has already happened.

You may ask why this is so? why do these lands so speedily succumb to the strangers from beyond the sea? One part of the answer is ready to hand with those who have learned one of the first principles of biology which our great master, Mr. Darwin, has laid down for us. The weaker, the more generalized forms of life must always make way for the stronger and more specialized. The other part of the answer is supplied by Mr. Wallace; for no one can have studied his volumes to much purpose without perceiving that the inhabitants of oceanic islands and of the southern hemisphere—the great Australian Region especially, and South America not much less, are the direct and comparatively speaking little-changed descendants of an older, a more generalized and a weaker fauna than are the present inhabitants of this quarter of the globe, which have been, so to speak. elaborated by nature and turned out as the latest and most perfect samples of her handiwork.

Set face to face with unlooked-for invaders, and forced into a contest with them from which there is no retreat, it is not in the least surprising that the natives should succumb. They have hitherto had to struggle for existence only with creatures of a like organization; and the issue of the contest which has been going on for ages is that, adapted to the condition under which they find themselves, they maintain their footing on the grounds of equality among one another, and so for centuries they may have "kept the noiseless tenor of their way." Suddenly man interferes and lets loose upon them an entirely new race of animals, which act and re-act in a thousand different fashions on their circumstances. It is not necessary that the new comers should be predacious; they may be so far void of offence as to abstain from assaulting the aboriginal population; but they occupy the same haunts and consume the same food. The fruit, the herbage, and other supplies that sufficed to support the ancient fauna now have to furnish forage for the invaders as well. Their effects on the flora there is no need for me to trace, since Dr. Hooker expressly made them one of the themes of that discourse to which many of us listened with rapt attention a few years since at this Association. But the consequences of the invasion to the native fauna have never been so fully made known. The new comers are creatures whose organization has been prepared by and for combat throughout generations innumerable. Their ancestors have been elevated in the scale of being by the discipline of strife. Their descendants inherit the developed qualities that enabled those ancestors to win a hard-fought existence when the animals around them were no higher in grade than those among which the descendants are now thrown. Can we doubt that the victory inclines to the heirs of the ancient conquerors? The struggle is like one between an army of veterans

and a population unused to warfare. It is that of Spaniards with matchlocks and coats of mail against Aztecs with feather cloaks and bows and arrows. *Mala salus victis.* A few years, and the majority of native species are exterminated. But this is not the worst. The species which perish most quickly are just those that naturalists would most wish to preserve; for they are those peculiar and endemic forms that in structure and constitution represent the ancient state of things upon the earth, and supply us with some of the most instructive evidence as to the order of nature.

With the progress of civilization it is plain that there will soon be hardly a land but will bear the standard of a European nation or of a community of European descent, and, as things are going on, be overrun by their imports. If this were inevitable, it would be useless to complain. But is it inevitable? Is it not obvious that most of this extermination is being carried on unwittingly, and may not some of it be avoided by proper precautions? If so, should not men of science make a stand, and interest the ignorant or careless in the importance of the subject? I cannot divest myself of the belief that the course of the next century will see the extirpation, not only of most of the peculiar faunas I had in view a few minutes ago, but of a great multitude of other species of animals throughout all parts of the world. The regret with which I regard such extirpation is not merely a matter of sentiment. Here sentiment and science are for once on the same side. A heavy blow will be inflicted on zoology by the disappearance of some of these marvellous and peculiar forms. There is no one species of animal whose structure and habits have been so completely investigated that absence of the means of further examination would not be a distinct deprivation to science; and as what Science has done is only an earnest of what she will do, we cannot say that the time shall ever come when the want of those means will not be severely felt. It is then for scientific men, and for naturalists especially, to consider whether they are not bound, in the interest of their successors, to interpose more than they have hitherto given any signs of doing.

But outside this audience there are many who care little for consequences like these. Such persons may, however, be impressed by thinking that the indiscriminate destruction of animals which, in one way or another, is now going on, must sooner or later lead to the extirpation of many of those which minister to our wants, whether of comfort or luxury. The fur-bearing creatures will speedily, if they do not already, require some protection to be generally accorded to them; and that such protection can be effectually given is evident if we take the trouble of inquiring as to the steps taken by the Russian local authorities in Alaska, and now, I believe, continued by those of the United States, for limiting the slaughter of the sea-otter and the fur-seals of the adjacent islands to particular seasons. No one can suppose that, even with the assistance we get from Siberia, our supply of ivory will con-

tinue what it now is when the interior of Africa is pacified and settled, as we can hardly doubt that it one day will be; and unless we can find some substitute for that useful substance before that day comes, it would be only prudent to do something to check the wasteful destruction of elephants. Many people may think that the continent of Africa is too vast, and its animal life too luxuriant, for the efforts of man materially to affect it. If we inquire, however, we shall find that this is not the case, and that there is an enormous tract of country, extending far beyond our colonies and the territories of the neighboring republics, from which most of the larger mammals have already disappeared. There is good reason to believe that at least one species has become extinct within the last five-and-twenty years or thereabouts; and though I do not mean to say that this species, the true zebra, had any economic value, yet its fate is an indication of what will befall its fellows; while to the zoologist its extirpation is a matter of moment, being probably the first case of the total extinction of a large terrestrial mammal since the remote days when the *Megaceros hibernicus* disappeared.

Time would fail me if I attempted to go into particulars with regard to the marine *Mammalia.* It is notorious that various members of the orders *Sirenia*, *Cetacea*, and *Pinnipedia*, have recently dwindled in numbers or altogether vanished from the earth. The manatee and dugong have been recklessly killed off from hundreds of localities where but a century or so since they abounded; and with them the stores of valuable oil that they furnish have been lost. That very remarkable Sirenian, the huge *Rhytina gigas* has become utterly extinct. The greed of whalers is believed to have had the same effect on a Cetacean (the *Balæna biscayensis*) which was once the cause of a flourishing industry on the coasts of France and Spain. The same greed has almost exterminated the right-whale of the northern seas, and is fast accomplishing the same end in the case of seals all over the world. You are probably aware that an Act of Parliament, passed in the session of 1875, was intended to put some check upon those bloody massacres that anually take place on the floating ice of the North Atlantic, to which these creatures resort at the time of bringing forth their young, when

"Sires, mothers, children in one carnage lie."

But, whether through official indifference, or what, I know not, the treaties with foreign nations authorized by that Act were not completed; and last spring, at the solicitation of certain Aberdeen or Peterhead shipowners, the Board of Trade allowed "one year more" of wholesale slaughter. Whatever other nations might like to do, our hands at least should have been unstained. It is admitted that in certain manufactures—that of jute, for instance—animal oil is absolutely necessary. It is easy to see that before long there will be very little animal oil forthcoming.

2. *List of papers read at the session of the National Academy of Sciences held at Philadelphia, Pa., October* 17*th*, 18*th*, *and* 19*th*, *1876.*—

Contributions to Meteorology, by Elias Loomis.

Upon the direct comparison of Solar radiation with that of the Bessemer Furnace, and upon the law of Dulong and Petit, by S. P. Langley.

On the affinities of Hypocephalus, by J. L. LeConte.

On a change in the relative length of the British Bronze and Iron Standard Yards in the U. S. Office of Weights and Measures, by J. E. Hilgard.

On sound in relation to Fog Signals, by Joseph Henry.

The Results of an Investigation upon the Transformations of Planorbis multiformis, by Alpheus Hyatt.

On the transmission of the shock of the explosion at Hell Gate, by H. L. Abbot.

On the geological structure and topographical aspects of the Catskill Mountains, by James Hall.

On the physical structure and altitudes of the Southern groups of the Catskill Mountains, by A. Guyot.

On the force involved in Crookes' Radiometer, by O. N. Rood.

On a new method of studying the reflexion of sound waves, by O. N. Rood.

On a property of the Retina first observed by Tait, by O. N. Rood.

On a series of molecular changes in the basaltic rocks of Lake Superior, by R. Pumpelly.

On the power of certain substances to abstract salts from their solution in water by filtration through them, by R. E. Rogers.

Note on the new compensation of a pendulum heretofore described, by J. Lawrence Smith.

The following is a list of the members elected at this session: G. F. Barker, Philadelphia, Pa.; Joel Asaph Allen, Cambridge, Mass.; William M. Gabb, Philadelphia, Pa.; E. S. Morse, Salem, Mass.; John Newton, U. S. Army.

3. *Proceedings of the Cincinnati Society of Natural History.*—No. 1 of these Proceedings, "January, 1876," has been recently published. Its twelve pages are occupied by a valuable paper on the Variation in form of the Family Strepomatidæ, with descriptions of new species, by A. G. Wetherby, which is illustrated by a plate of fifteen figures representing the new species, *Lithasia plicata*, *Angitrema parva*, *Goniobasis plicato-striata*, *Anculosa umbilicata*, *Angitrema angulata*.

4. *The Scientific Monthly, a Magazine devoted to the Natural Sciences.* E. H. Fitch, editor and proprietor, Toledo, Ohio.—The August number of this monthly, No. 11 of the first volume, contains various papers of popular interest. The first, by Dr. T. A. Fitch, continues an article on Springs, which is illustrated by a plate giving a view of a mud volcano.

5. *The Universal Metric System*, by Andrew Colin, M. E., Principal of a Preparatory Scientific School. 50 pp. 12mo. New York, 1876. (D. Appleton & Co.)—This little work was prepared, as the author states, "especially for candidates for schools of science, engineers and others;" and it is well adapted for its purpose, and for the wider one of fitting all students of the higher schools or academies of the country for the easy use of the metric system in calculations. The expression universal is applied to the system because, although first adopted by the French, "almost all the nations of the world have now adopted it," and its use will undoubtedly be soon actually universal. The explanations of the subject are simple and precise; and numerous problems are given, occupying eighteen pages, in order to make the work a good class-book.

6. *Bulletin of the Minnesota Academy of Natural Sciences, for the year* 1875. 44 pp. 8vo.—This Bulletin contains a paper by Prof. N. H. WINCHELL on early explorers of the Minnesota valley (continued); a report on Ornithology by Dr. F. L. HATCH; notes on Entomology, by R. J. MENDENHALL, treating of some noxious insects; notes on a storm on the 18th of July, 1867, over Pope and Douglass counties, Minnesota, by G. B. WRIGHT, the rainfall of which, in Sauk Centre, amounted to at least "30 inches and probably reached 36 inches;" meteorological statistics, by WILLIAM CHENEY; and notes on a deep well drilled at East Minneapolis; by N. H. WINCHELL. The depth of this well was 1421 feet, and it descended, after passing the surface soil, through the Trenton limestone and subjacent strata, to a clayey sandstone of the Primordial—the formation that affords the well known "pipestone" or *catlinite*, of Minnesota.

7. *Arrangements for a Meeting of the British Association—an example worth following.*—When the British Association met at Belfast (we cite from the Athenæum for Sept. 9), an excellent guide-book was prepared for the occasion and presented to members of Committees. In 1875, the promoters of the Bristol meeting, following up the experiment, brought out a larger and more elaborate hand-book. This year, at Glasgow, the scheme was further extended, and on Wednesday morning the members were surprised by the issue of a work in three volumes, one describing the geology of the district, another its fauna and flora, and the third its manufactures. Moreover several scientific collections were specially got up in view of the meeting, and nearly a hundred factories were thrown open for inspection. Besides, there were popular evening lectures outside of the work of the Association: on Monday evening, by Sir Wyville Thomson on the Challenger Expedition, on Tuesday evening, by Commander Cameron on his African explorations, and Saturday evening, by the same, to the workingmen of Glasgow. In addition, the excursions while of various kinds, were mainly for scientific purposes.

The following works were received too late to be here noticed:

Reports on the Geological Survey of Pennsylvania, by J. J. Stevenson and Professor Frazer, Jr.

Zoology of Lieut. Wheeler's Expedition. 1020 pp. 4to. with many plates, part of them colored.

The American Bisons, living and extinct, by J. A. Allen. 246 pp. 4to, with 12 plates. Memoirs of the Mus. Compar. Zool., Cambridge, Mass.

Monograph of American Trilobites, Part I; by A. Vogdes, U. S. A. 16 pp. Tampa, Florida. 1876.

OBITUARY.

CHARLES SAINTE-CLAIRE DEVILLE, the distinguished geologist and meteorologist, died on the 10th of October, aged 62 years. He was, at the time of his death, Inspector-General of the French Meteorological Stations. A notice in *Nature*, speaks of his singular modesty, and states that "in accordance with a desire expressed in his will, no official deputation of the Academy was present at his funeral, and no funeral oration was pronounced over his grave."

APPENDIX.

ART. L.—*Principal Characters of American Pterodactyls*;* by Professor O. C. MARSH.

THE remains of *Pterosauria*, or flying lizards, hitherto found in this country, are all from the Upper Cretaceous deposits of Kansas. They are remarkable for their large size, some having a spread of wings not less than twenty-five feet. They differ widely from the Pterodactyls of the old world, especially in the *absence of teeth*, and hence have been placed by the writer in a new order, *Pteranodontia*,† from the typical genus *Pteranodon*.

In this genus, the skull is much elongated. The orbits, and the antorbital and nasal apertures are large. The maxillary and premaxillary bones are coossified, and entirely edentulous. The atlas and axis are united. The scapular arch presents some peculiar features, not before known in any vertebrate. The scapula, which is firmly coossified with the coracoid, has at its distal end an oblique articular face. This articulation is separated from the corresponding facet of the opposite scapula by a thin median plate, which is apparently a neural spine of a dorsal vertebra. The two scapulæ thus brace each other, and aid in securing powerful flight. In *Pteranodon* the fourth finger is greatly elongated, and the wing metacarpal is longer than half the antebrachium, There are five separate carpal bones, beside the pteroid bone which supported the membrane. The pteroid is not a true carpal, but is perhaps homologous with the small bone in the foot of a bat which supports the patagium. The first three metacarpals are very slender, pointed above, and do not reach the carpus. At their distal end they supported sharp, curved claws. In some species, the distal phalanx of the wing finger is not straight, but falciform.

The pelvis in *Pteranodon* is of moderate size. The ilia are elongate. and the acetabulum is imperforate. The ischia are broad, and united on the median line. The tail is short and slender, and the distal caudals are sometimes coossified. The posterior limbs are well developed. The tibia has at its distal end a pulley-like articular surface. There are two tarsal bones of

* Abstract of a paper read before the American Association for the Advancement of Science, at Buffalo, Aug. 28th, 1876.

† This Journal, vol. xi, p. 507, June, 1876.

nearly equal size, and a small lateral bone, which may possibly be the distal end of the fibula. There are four metatarsals of nearly the same length, and their ungual phalanges are pointed, but not much curved.

The known species of *Pteranodon* are as follows: *Pteranodon occidentalis* Marsh (*Ornithochirus harpyia* Cope), *Pteranodon ingens* Marsh (*Ornithochirus umbrosus* Cope), *Pteranodon velox* Marsh, *Pteranodon longiceps* Marsh, and *Pteranodon comptus* Marsh.

Nyctosaurus, gen. nov.

A second genus of American Pterodactyls is represented in the Yale Museum by several well preserved specimens. This genus is nearly related to *Pteranodon*, but may be readily distinguished from it by the scapular arch, in which the coracoid is not coossified with the scapula The latter bone, moreover, has no articulation at its distal end, which is comparatively thin and expanded. The type of this genus is *Pteranodon gracilis* Marsh, which may now be called *Nyctosaurus gracilis.* It was a Pterodactyl of medium size, measuring about eight to ten feet between the tips of the expanded wings. Its locality is in the upper Cretaceous of Western Kansas. The type specimens of all the above species are preserved in the Museum of Yale College.

INDEX TO VOLUME XII.*

* The Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, ZOOLOGY, and under each the titles of Articles referring thereto are collected.